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USE OF ELECTROSURGERY IN NEUROLOGICAL SURGERY*

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THE surgery of lesions of the central nervous system, particularly those situated within the intracranial cavity, calls upon the surgeon to meet a number of factors inherently difficult in the nature of the operative field. The dynamics of the cerebrospinal fluid, the lack of resistance which nerve tissue affords against infection, and the necessity for making both an accurate localizing and pathological diagnosis before operation, are but a few of the problems which must be controlled to achieve successful results in this field of surgery.

Here, as elsewhere in surgery, one of the great problems is to control and to diminish the effects of hemorrhage as far as is possible. Among the devices which have been developed toward these ends in the progress of neurological surgery may be mentioned the use of silver clips, of muscle implantations, of tissue fixation *in situ*, and if necessary the coincident or subsequent employment of blood transfusions or refusion with the patient's own blood which has been collected from the wound by a suction apparatus. Lately another principle, that of electrosurgery, has come to be employed not only as a means of perfecting hemostasis in intracranial operations in general but as a direct aid to the successful treatment of certain types of lesions.

In 1600, William Gilbert,[1] surgeon to Queen Elizabeth, published his great work "De Magnete" and in it laid the foundation for the development of the use of electrical currents in medical science. In 1780, Galvani[2] accidentally discovered that muscular contractions could be produced by an electric current. Later this particular type of current was used in the development of the galvanocautery which produces a dissolution of tissue by chemical action. In 1888, Hertz[3] succeeded in producing a series of electric oscillations of a very high frequency. Shortly after this Tesla[4] produced heat within the tissues as a result of the passage of an electric current of high frequency. In the same year, D'Arsonval[5] stated that it was possible to pass a high frequency current of 3 amperes through the body with the production of no other sensation than that of heat. He found that a current which alternated less than fifteen times per second produced clonic muscular contractions, while one which alternated twenty or thirty times per second produced a tonic contraction. As the frequency increased to a maximum of about 300 oscillations per second the intensity of the tonic contraction increased. However, beyond this rate it became less intense until at a frequency of about 10,000 per second all muscular contractions ceased.

Shortly after this communication of D'Arsonval, attempts were made to employ electric energy in the form of high frequency currents upon neoplasms. Ful-

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guration or sparking was looked upon by early investigators as a possible and valuable factor in the destruction of neoplasms.

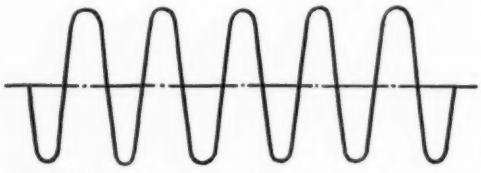

Fig. 1. Undamped wave which will cut but has very little dehydration effect.

The ever-present, although uncontrollable, long spark from the high voltage apparatus was recognized as a possible factor of great value in cauterizing and carbonizing malignant tumors. In 1907, Possi[6] reported the cure of superficial and even deep-seated carcinoma by the action of sparks from the terminal of an Oudin resonator. However, subsequent investigation has shown that fulguration merely raises the local temperature to an enormous height and carbonizes the neoplasm superficially, thereby defeating the very purpose it aims to attain. Deeper destruction of the neoplasm is thus prevented by protective carbonization which is produced by the spark. In 1908, Nagelschmidt[7] demonstrated a specially designed apparatus of high frequency, with lower voltage and improved resonance. The surgical application of this type of apparatus in the coagulation of malignant growths was introduced first by Doyen.[8]

To obtain a clear understanding of the field of electrosurgery, it is essential to understand clearly the terms found in the literature. Medical diathermy, for example, is that type of high frequency which will keep the heat within physiological limits, and which does not lead to damage of the tissue. On the other hand, surgical diathermy is the use of high frequency currents to produce cellular destruction proportional to the degree of heat created within the tissues. To avoid confusion in the use of these two terms, the word electrosurgery has been introduced by Cushing[9] to describe the use of surgical diathermy. Fulguration, electrolysis, galvanocautery, Paquelin cautery and the Percy cautery differ from electrosurgery in that the heat is generated in the applica-

Fig. 2. Highly damped wave which will not cut but has excellent coagulation qualities.

tors themselves which are always hot when applied. The effect of these latter procedures is to cauterize or burn the tissue which under the conditions of neurological surgery is undesirable. In electrosurgery the heat is generated after the applicator has made contact with the tissues.

The currents applied for electrosurgical purposes must be of such high frequency that the electrical shocks, chemical action, molecular changes and lethal effects associated with ordinary commercial currents may be entirely absent. This means that the direction of the flow of current must be reversed at a rate of upwards of a million times per second. A variety of effects may be produced depending upon the type of tissue operated upon and the characteristic of the high frequency current used. In speaking of the character of a current we mean the frequency and type of alternations in the direction of the flow of current. The alternations of the current may be regular, or they may die out and then after an interval of time start in again, either suddenly or slowly. The regular current is referred to as "un-"damped" (Fig. 1) and the irregular as "damped" (Fig. 2). It will be noted that an undamped or continuous wave current flows with practically a continuous application of energy, substantially uniform in rate and amplitude. However, the fact that a current is of high frequency does not necessarily suit it to electrosurgery. Even though a pure undamped or continuous wave current has excellent cutting quali-

ties, it offers no advantages over the ordinary scalpel, because it has very little hemostatic effect upon the severed edges of the tissues. However if the active electrode is energized with a frequency current which has wave trains which lie between those of the undamped and highly damped current, tissues may be cut and at the same time the surfaces will be dehydrated (Fig. 3). Thus by variation of the amount of damping any degree of hemostasis can be obtained. Through this modification of the wave train the action of the current may be changed from free cutting without dehydration and coagulation, to coagulation and dehydration without cutting. It is therefore possible to modulate the current in accordance with the vascularity of the tissues which are to be incised.

In electrosurgery there are three distinct ways in which the high frequency current may be used: (1) dessication or dehydration, (2) cutting, (3) coagulation.

Electrodessication embraces the effect of drying or dehydration of the tissues. Histologically, the effect is what is to be expected from the application of a very mild dehydrating agency with the production of mummification. The cell outline is barely visible and because the water has been literally boiled out, the protoplasm is dried. The death of the cell is associated with very little degenerative change and with a small amount of necrotic material so that but a small amount of fibrous tissue is formed. To obtain this effect the active electrode is not in contact with the tissues. However, it is sufficiently close so that sparks are sprayed across the gap between the electrode and tissue. The temperature of these sparks is sufficiently high to produce superficial dehydration.

In neurological surgery, cutting with the electrosurgical current may be done with needles, small blunt blades, or loops made of wire. Sharpened blades are unnecessary because the electrode itself does not actually sever the tissues. This is accomplished by the current which forms an electrical arc ahead of the electrode. The tissues are thus separated by volatilization as though they were cut. Depending upon the vascularity of the tissues,

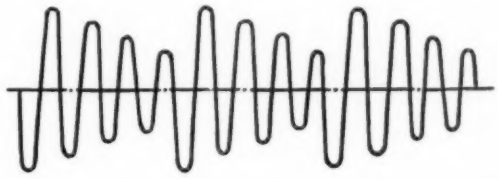

Fig. 3. Moderately damped wave which has excellent cutting qualities and gives a light degree of dehydration.

the cutting current may be damped proportionately to produce coagulation.

Histologically, electrocoagulation produces a complete cellular necrosis with a variable inflammatory reaction in the adjacent tissues. There is also produced thrombosis and hyalinization of the blood vessels, small round cell infiltration and fibrosis. When an electrode is energized by such a highly damped current, there is not the slightest indication of a cutting action. Instead the electrode is immobile. The mass or amount of coagulated tissue is governed by the power used and the length of time the current is applied. If heavy power is used and the current is applied for a short time a thin depth of coagulated tissue will result. If the current is of high power and is applied too long, it will tend to char and carbonize the tissue which under ordinary circumstances would be undesirable. To produce a heavy depth of coagulated tissue without carbonization, requires the application of a smaller amount of power over a relatively longer period of time. This type of current has a great many surgical uses other than the destruction of pathological tissue. It may be used in the sealing off of small and medium-sized blood vessels in the cortex of the brain, or on the surface of a meningioma. By picking up the vessel with the forceps, or hemostat, and then touching the instrument with the active electrode, it will be found that the vessel grasped will be coagulated. This may be done either before or after the vessel has been severed. By this means

the use of silver clips, while they are not dispensed with entirely, can be reduced to a minimum. It is obvious that the chief advantage of the electrosurgical current is the fact that its dehydrating powers can be varied at will.

Progress in the treatment of intracranial lesions can be traced along three lines: (1) accurate localization, (2) improved surgical technic and (3) pathological classification of the tumors encountered. At present, one must consider preoperatively not only the exact location of the lesion but there should be a rather definite idea of just which type of tumor may be uncovered. So it is that neurologic surgeons are speaking of the location and behavior of particular tumors rather than of intracranial tumors as a whole and the general effects of intracranial pressure. It is to the surgical treatment of certain of the intracranial tumors that electrosurgery lends itself and to Cushing belongs the credit of first using it in craniocerebral surgery.

It must not be assumed that the advent of electrosurgery has meant the abandonment of the principles of osteoplastic intracranial operations. It has meant only that the successful removal of certain tumors, both encapsulated and otherwise, has been advanced considerably and that a valuable addition has been made to the surgeon's armamentarium.

MENINGIOMAS

Meningiomas may vary in their gross appearance and microscopic structure yet they are all similar in their origin from the cells of the arachnoid. Some of them produce hyperostoses from invasion of the haversian canaliculi; some cause a pressure atrophy of bone, while others produce no bone change whatever. However, they have favored points of origin and in each instance produce symptoms which give rise to a recognizable syndrome. Some arise from the meninges over the surface of the cortex and form a globular tumor mass which may be removed with comparative ease. Still another group arise from the olfactory groove, and others from the basilar meninges about the sella turcica. Other meningiomas may be attached to the falx cerebri; to the sphenoidal ridge lateral to the sella turcica; or other flat growths which spread over the meninges covering the anterior and lower part of the temporal lobe may produce no intracranial symptoms and yet are associated with a unilateral exophthalmos and marked thickening of the bone of the lateral wall of the orbit and the temporal fossa.

Because of their benign character the meningiomas are considered to be the most favorable group of intracranial tumors for surgical removal. However, they may attain an enormous size, often with invasion of the bone, before they are recognized. They are usually attached to the dura mater near the cranial sinuses and unless this point of origin is removed it is likely that the tumor will recur. Consequently they may be situated in locations very difficult of access. Even when they are more accessible, it may be necessary to ligate large sinuses, a step which may be followed by a train of mechanical circulatory disturbances. So it is that many times they are looked upon by the surgeon with a great deal of trepidation. The following case will serve to illustrate the use of electrosurgery in the surgical treatment of these tumors.

Right primary optic atrophy. Left papilledema. Bilateral anosmia. Mental bebetude. First stage transfrontal osteoplastic flap. Second stage removal of olfactory groove meningioma. Recovery.

Mrs. C. C., Wesley Memorial Hospital, No. 139448, aged fifty-one, was referred by Dr. F. C. Warne of Chicago, on July 20, 1928.

History: In 1920, the patient consulted an ophthalmologist who diagnosed an optic atrophy in the right eye. Nothing further was done about this until in 1927 she became listless, disinterested and unable to carry on her housework. Lately she had slept most of the time. There was no complaint of headache or vomiting.

Examination: The right pupil reacted only slightly to light but the left reacted promptly.

Vision was lost entirely in the right field and was diminished in the left with greater loss on the temporal side. There was a complete

Fig. 4. Drawing elaborated from operative sketch which shows meningioma below frontal lobe.

primary optic atrophy in the right eye. The retinal veins of the left eye were engorged and there was a beginning papilledema. There was a bilateral loss of olfactory sense. Movements of the left hand were clumsier than the right. The left upper extremity fell away when held extended. Deep tendon reflexes in the left upper extremity were greater than on the right. *X*-ray examination of the skull showed a thickening of the floor of the right frontal fossa and an indistinct outline of the clinoid processes of the sella turcica.

Diagnosis: A preoperative diagnosis was made of a meningioma lying in the right frontal fossa. The syndrome of unilateral optic atrophy, anosmia and mental symptoms made it appear likely that the tumor originated from the olfactory groove.

Operation: Upon August 2, 1928, a right transfrontal osteoplastic flap was turned down under local anesthesia. There was considerable bleeding from the bone and scalp which was difficult to control. Therefore the flap was replaced without opening the dura mater and a second stage operation was decided upon.

On August 7, 1928, the tumor was exposed. It proved to be a large meningioma which occupied the right frontal fossa and extended beyond the median line to the left. It was attached about the olfactory groove. The frontal lobe was retracted upward and it was obvious that the tumor could not be tilted out of its bed by traction sutures (Fig. 4). With the electrosurgical unit the tumor was incised and

Fig. 5. Patient on day of discharge from hospital. Note inconspicuous wound.

then the inside was looped out with the coagulating current. This was continued until the tumor had been entirely removed from the floor of the fossa. Successive attempts to tilt the capsule of the tumor by silk sutures met with failure. The tumor was therefore removed in scallops down to its attachment and this was sprayed with the current to kill any tumor tissue which might remain.

Course: The patient made a good recovery and was discharged from the hospital September 13, 1928 (Fig. 5). A year later the patient was attending to her household duties and was in excellent condition. Her visual field on the left increased but the vision in the right eye remained unchanged. Microscopic examination proved the tumor to be a typical meningioma (Fig. 6).

Comment: This then was a patient of middle life who had developed a bilateral anosmia of which she was unaware; a complete blindness in the right eye with primary optic atrophy; mental symptoms

and involvement of one upper extremity because of an increase in intracranial tension. The latter had only recently

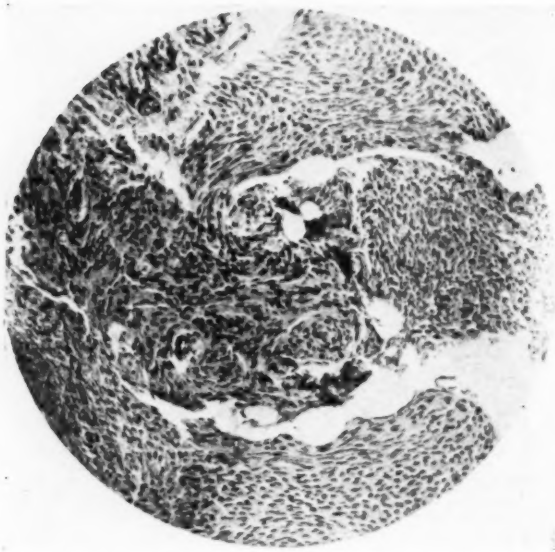

Fig. 6. Photomicrograph of meningiona removed. Van Gieson stain.

produced the first evidences of a beginning contralateral papilledema. Foster Kennedy[10] first called attention to this syndrome and recently Cushing[11] has considered these olfactory grove meningiomas in his Macewen lecture.

It has been the aim to remove meningiomas intact at one operation, but even when they are situated more favorably this may prove to be a difficult proceeding because of the extreme vascularity of the tumor, its attachments and the surrounding tissues. It may be imagined what trauma to the overlying frontal lobe might ensue and what uncontrollable hemorrhage might accompany an attempt to remove a tumor in such a location.

It is under such circumstances that the use of an electrosurgical unit has proved so valuable. It has resolved itself into the application of the well-known principle of an intracapsular enucleation such as has been used in the past for the removal of acoustic neurinomas. In other words we now have at our command a method by which a relatively inaccessible, highly svascular, tumor may be removed in it entirety which previously would most certainly have proved inoperable. Though more accessible meningiomas have been removed in the past with success, nevertheless they are now approached with less fear of the necessity of multiple operations or of blood transfusions or refusions as life-saving measures.

GLIOMAS

The use of electrosurgery in the surgical treatment of the gliomas offers a more difficult problem than that presented by the meningiomas. It is however even of more importance when we realize that this group constitutes 42 per cent of all intracranial tumors. The problem of dehydrating, coagulating or cutting through gelatinous, soft, spongy, tumor tissues is so different that an attempt to loop out the tumor is in the majority of instances impossible.

The histological classification of the gliomas according to the predominance of glia cell types has been a tremendous step forward in our knowledge of the clinical course and surgical possibilities offered by these tumors. We have learned that the spongioblastoma multiforme is the most malignant of the gliomas and that a complete surgical removal is practically impossible. But we have also learned that the astrocytomas, the hemangioblastomas, and the slowly growing oligodendrogliomas offer encouraging and often brilliant results from surgical treatment. To this list through the work of Cushing with the aid of the electrosurgical unit, we may now add the medulloblastomas, a tumor most frequently found in children arising within the fourth ventricle. Many times it is necessary to split the vermis of the cerebellum to expose these tumors adequately. The technic of this procedure has been simplified immeasurably by the use of the combined cutting and coagulating current. While these tumors are soft they are nevertheless of firm enough structure to make their removal by the loop electrode possible. However, control of the vessels

entering these tumors laterally and below is the greatest problem to be met. Electrocoagulation is simpler and safer than the use of silver clips. When one realizes the size which these tumors attain and the physical condition in which we find these young patients after protracted vomiting bouts, any method which adds to the comfort of the surgeon is welcomed.

In our hands the electrosurgical unit has not added to our successful treatment of the large succulent, infiltrating spongioblastomas. These soft, gelatinous, cystic tumors do not lend themselves to piecemeal removal by electrosurgery. Yet even here the removal of a large block of cerebral tissue including the tumor is made less difficult by coagulation of the cortical and subcortical vessels. One may thus work in a comparatively avascular field. It is in such tumors that a partial or total lobectomy must be considered and while we are not in accord entirely with such radical procedures, nevertheless electrosurgery has made such a procedure less formidable.

However, as we stated, it is with the firmer and better defined gliomas that electrosurgery has proved of inestimable value. Our experiences with such situations may be illustrated by the following case.

Headaches, bilateral papilledema, uncinate seizures without localizing symptoms. Right subtemporal decompression. Relief of headaches and subsidence of papilledema. Recovery and return to work—One year later return of uncinate attacks. Weakness of right arm and right side of face. Ventriculograms showed filling defect of left inferior horn. Left osteoplastic craniotomy. Removal of astrocytoma from left temporal lobe. Recovery.

Mr. George W., aged thirty-six, was referred by Dr. T. A. Baumann of Rockford, Illinois, on January 1, 1928.

History: Since July of 1927 the patient has complained of severe headaches accompanied by vomiting. At that time he began to have attacks of loss of consciousness, lasting a short time and always preceded by a bad odor and taste. These attacks had occurred as often as three times daily. In November of that year he noted a marked diminution of vision.

Examination: The patient was in extreme pain from his terrific headaches which could be relieved for short intervals by hypertonic glucose solution. There were no neurologic findings which pointed to a lateralization of his intracranial lesion. There was a bilateral papilledema and a marked enlargement of his blind spots.

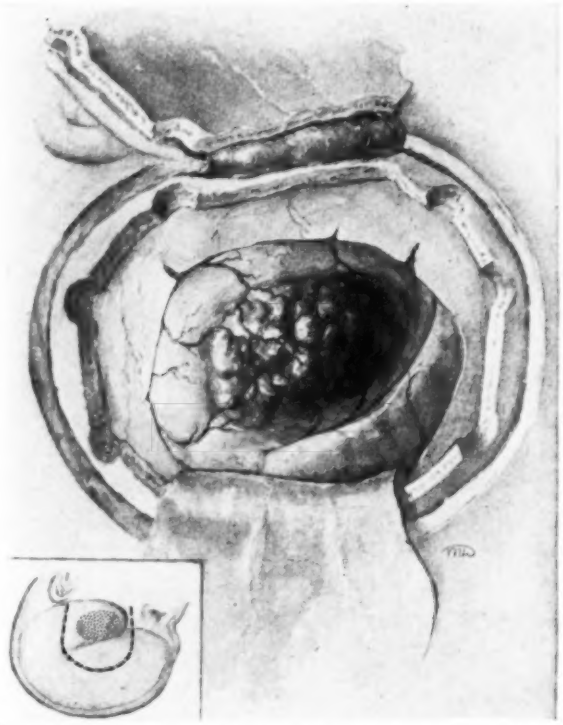

Fig. 7. Drawing elaborated from operative sketch which shows surface appearance of large glioma in temporal lobe.

Operation: On January 6, 1928, a right subtemporal decompression was performed. The postoperative recovery was excellent. The headaches were relieved completely and there was a rapid subsidence of his papilledema. The patient returned to work but was examined monthly for evidence of localization.

Re-entry: On December 8, 1929, the patient was readmitted to the hospital. There had been a return of his uncinate attacks and he now presented a slight weakness of the right side of the face and of the right arm. He did not complain of headaches and his optic discs were flat.

Ventriculography: A ventricular study was done and air was injected. The ventriculograms showed a filling defect in the tip of the inferior horn of the left lateral ventricle.

Operation: On December 10, 1929, a left osteoplastic flap was made and the temporal lobe was exposed. The anterior portion of this

lobe was soft, yellow in appearance and relatively avascular (Fig. 7).

With the ball electrode of the electrosurgical unit the surface vessels were coagulated (Fig. 8a). The cortex was then incised longitudinally with the flat blade electrode (Fig. 8b). The brain tissue fell open in the characteristic manner and the tumor tissue was looped out with the electrode (Fig. 8c). As we got into the tumor we found that it was soft and gelatinous and the sucker was used to remove a great part of it. Soft tumor tissue could be seen extending medially and posteriorly and consequently remaining temporal lobe tissue was removed intact back to normal appearing cortex. That part of the tumor which remained on the floor of the middle fossa was removed with the loop electrode. The inferior horn of the ventricle was thus opened. At this stage a large subcortical vessel was ruptured. This was grasped with a tissue forceps and coagulated. A piece of muscle tissue from the patient's leg was placed over the opening in the lateral ventricle. After we had obtained a clean, dry wound the bone flap was replaced after the cavity was filled with saline solution.

Course: The patient's convalescence was quite remarkable and he left the hospital December 21, 1929 (Fig. 9). There was no temperature reaction and no evidence of a late secondary hemorrhage. Microscopic examination proved the tumor to be an astrocytoma (Fig. 10). The patient has remained well and free from all symptoms and is now at work upon a farm.

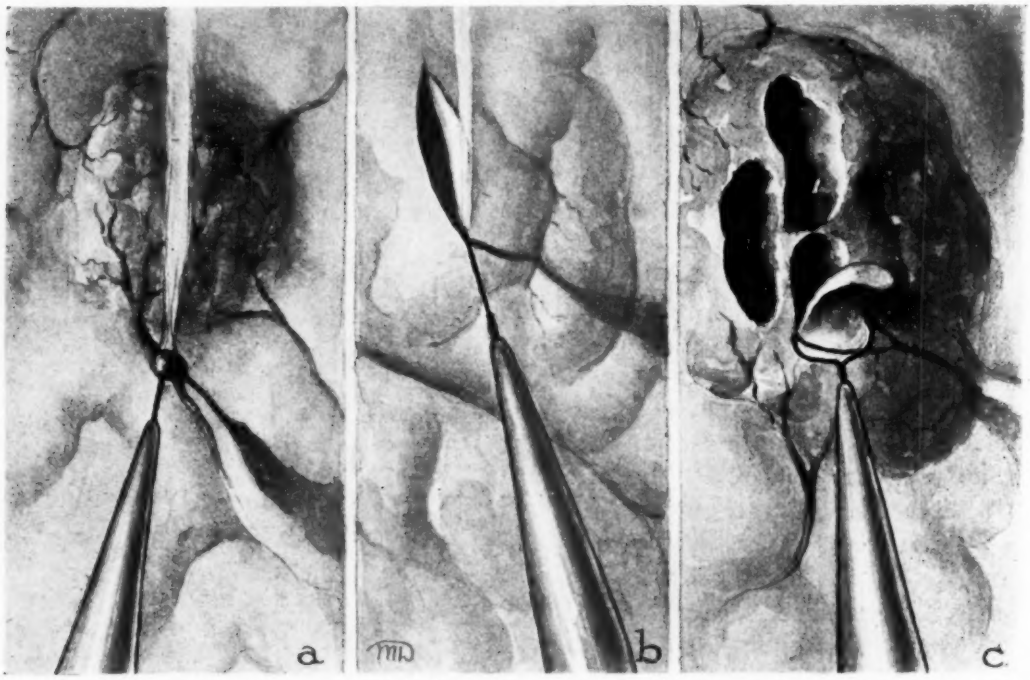

Fig. 8. a, Coagulation of surface vessels with ball electrode; b, incision of cortex with flat blade electrode; c, removal of tumor with loop electrode.

Comment: In the past the technic of attacking such a tumor has been to ligate the superficial vessels with silver clips, to cut through the cortex and then by cotton pledglet dissection to circumscribe the growth. After the tumor has been uncapped in such a fashion the softer gliomas have been handled quite advantageously by use of the sucker. One should not gain the impression that electrosurgery has superceded this technic completely. What has been added is the greater ease with which cortical or subcortical vessels are treated. It is far simpler to keep the field of operation free from blood, and in removing gliomatous tumor tissue it is extremely important to keep the plane of dissection dry. Moreover, it is of the greatest importance to uncap the tumor widely, particularly if it lies subcortically before attempting its removal. To effect

this step the coagulating current is a great aid. Nothing is of a greater disadvantage than to have bleeding occur which spreads

Fig. 9. Patient upon day of discharge from hospital. Note inconspicuous wound.

into normal cortical tissue. This only adds to the difficulty which already exists in determining the extent of a glioma into the surrounding normal brain tissue.

It must be emphasized that the electrode is of little use in soft, gelatinous tumor tissue and it is under such conditions that one must rely, as we have in the past, upon the suction apparatus. Further, larger subcortical vessels may be encountered which cannot be coagulated with safety, and consequently we cannot dispense with the use of silver clips. However, we feel that the addition of the electrosurgical unit has allowed us to be more radical in the removal of subcortical gliomas with greater safety to the patient and the experience cited here is an illustration.

There is no doubt that the use of the current produces some change in the adjacent brain tissue which remains be-

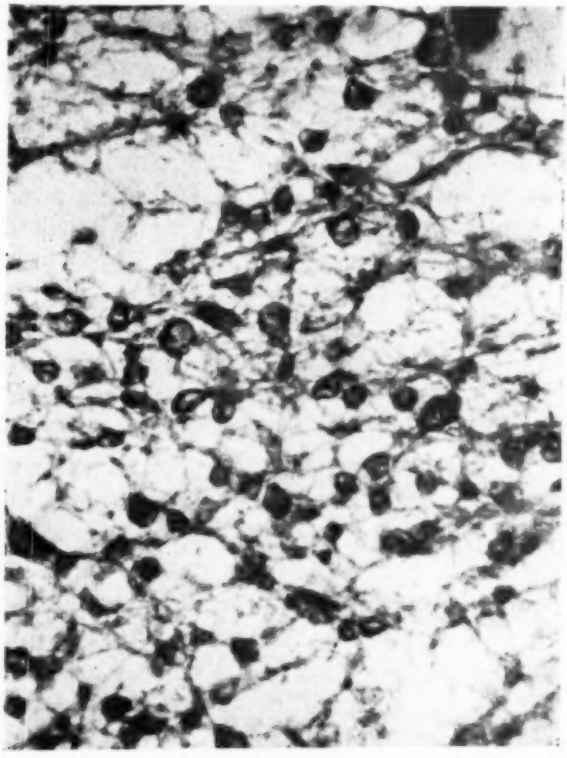

Fig. 10. Photomicrograph of tumor removed. H and E stain, Leitz objective 10 ×, ocular 6 ×.

hind. This is not represented by a charred, necrotic surface which may be expected to slough. In fact the change is not a macroscopic one. However, microscopic sections show a loss of the staining qualities which normal brain tissue possesses.

OTHER INTRACRANIAL TUMORS

Angiomas: While these tumors are comparatively speaking of infrequent occurrence within the brain, one needs only to meet with one at operation to be impressed with the difficulties surrounding their surgical treatment. To expose a mass of vessels which resemble more than anything a tangled mass of angleworms and to judge the wisest procedure to employ is a situation which taxes one's surgical judgment. Even the help of the coagulating electrode is not the all-encompassing comfort that it might seem to be.

However, by beginning with vessels

at the periphery of the lesion and by the use of a slow coagulating current, in many instances we may reduce these tumors to a shrunken charred mass. The greater danger lies in attempting to coagulate the vessels too rapidly. The wall of one of these aneurysmal vessels may be sparked through and troublesome, if not uncontrollable, bleeding occurs. Certainly, before the use of electrosurgical methods the treatment of these lesions consisted entirely of a decompression operation and the use of *x*-ray therapy.

Acoustic Neurinomas: These encapsulated tumors arise from the eighth cranial nerve in its short intracranial course. They occupy the space known as the cerebellopontile angle, and therefore by pressure involve the cerebellum, pons and other cranial nerves which arise from the lateral aspect of the pons and medulla. While they are quite benign in themselves, their increase in size gives rise to a clinical syndrome of disabling symptoms which are characterized by the chronology of their development. They are rather easily recognized but their surgical exposure offers a serious problem.

The surgical removal of these tumors must be governed in part, at least, by the fact that in one's desire to remove the entire growth irreparable damage may be done to the adjacent nerve structures. In the past we have been content to remove the tumor tissue by incising the capsule, and to leave the latter structure in place. When one visualizes the vessels which supply the tumor and which come from the pons, the uncontrollable hemorrhage which may be encountered is easily understood. A further difficulty is offered by the fact that these medial vascular attachments of the tumor to the pons cannot be visualized clearly.

Electrosurgery has afforded several distinct advantages. First, intracapsular removal by looping out the tumor tissue may be done more quickly and quite bloodlessly. The loose capsule may then be removed by carefully coagulating each of the vessels leading into the tumor. This is easier to do than to place silver clips on these vessels in a necessarily deep wound. Moreover, many of these tumors are situated rather high in the angle and the overlying cerebellar cortex makes it difficult to obtain a satisfactory view of the mass. Under such conditions removal of the lateral portion of the cerebellar hemisphere would be of considerable help. In the past such a procedure was tedious, slow, and likely to be accompanied by more damage than was desirable. It has been shown that such a removal of a portion of the cerebellar hemisphere may be compensated for by the patient. The use of the electrode makes it possible to remove this part of the cerebellar lobe rapidly and without loss of blood. The resulting symptoms may prove to be less formidable than those produced by the necessary retraction of a cerebellar hemisphere which is left in place.

SUMMARY

There can be no doubt that the use of electrosurgery adds a complex piece of surgical equipment to a technic already dependent upon meticulous attention to detail for its success. The surgeon, of course, does not have to be acquainted with all of the laws of electrical physics to employ such an apparatus successfully. However, a thorough acquaintance with its performance obtained upon experimental living structures is necessary before one should attempt its use during a complicated surgical procedure. Even with such a preparation, the advantages and limitations of its use are indicated more clearly by practice. That some surgeons may find it of more value than others to gain the same result is a fact which depends entirely upon the individual's surgical technic. It should be emphasized again, therefore, that electrosurgery cannot be said to have superceded the basic principles of osteoplastic cranial operations and tumor removal.

It has been our experience that one is likely to hurry the procedures of coagulat-

ing vessels or incising brain tissue. As has been pointed out, the use of a strong current to coagulate a vessel may cause it to explode and to defeat the object for which it is intended. It is certain that the electrodes are of no service whatever in a bloody field which does not allow one to see the bleeding or oozing point.

It is of course understood that an electrosurgical apparatus should not be used during the administration of a general anesthetic. The possibility of an explosion is too factual to be dimissed. Consequently the operations in which the electrodes are used are performed under local anesthesia. The disadvantages of a general anesthetic such as ether in intracranial operations are well known, so that the necessity of a local anesthetic in itself is of value. However, it must be recognized that many individuals are not suitable patients for the use of local anesthesia. In such circumstances we have taken the precaution to remove the ether bottle from the room, and have placed a wet cloth between the patient's face and the operative field while the unit is in use.

We have satisfied ourselves that there are not untoward or disturbing complications due to the use of this apparatus in intracranial surgery. As a matter of fact the immediate postoperative convalescence in all the cases in which it has been used has been smooth and uneventful. We have never had to re-elevate a flap in this group of cases because of secondary hemorrhage. Neither do we believe that any greater amount of postoperative edema follows its use.

In conclusion, we believe that:

1. Electrosurgery is a distinct addition to the neurological surgeon's armamentarium. It does not however completely supercede the well established principles of osteoplastic craniocerebral surgery.

2. At present, it may be employed to its greatest extent in the removal of meningiomas; in particular, to the relatively inaccessible meningiomas.

3. The improvement of the use of electrosurgery in the surgical treatment of gliomas offers the possibility for its greatest contribution to the surgery of the nervous system.

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NEPHROPTOSIS

ITS RELATION TO THE LIVER, SPLEEN, STOMACH AND ITS CORRECTION BY MEANS OF A NEW OPERATION

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FOR several years, the author has been confronted with a number of cases which have presented a complex train of symptoms referable to urinary, gastrointestinal, biliary and nervous systems. Many of these patients have passed from one branch of medicine to another without obtaining relief of symptoms after much internal medication and in some instances even after surgical procedures had been tried. The symptom complex has led the physician to the ptosed kidney condition as representing the paramount pathological lesion, but its relation to hepatoptosis, cholecystitis, general visceroptosis, kinks and strictures of the ureter, infections of the kidney, rotations of the kidney, pelvic capacity and kidney functions has not been clearly defined. It is the twofold purpose of this paper first to present the data obtained from a study of a series of such nephroptotic cases and secondly to submit a new operation for nephroptosis.

While the nephroptotic kidney case is a frequent visitor to the urological clinic it is difficult to find a large series of these cases which have been so thoroughly studied that one may extract the details relative to size, shape, position, function and mobility of all the viscera.

In all 55 cases were available for study. These were all cystoscoped routinely. The phenolsulphonphthalein functional tests were done intravenously, the urines were examined immediately and cultured, the capacity of the kidney pelvis measured, the *x*-rays were taken with the patients in the supine and erect positions. Where the stomach was not outlined by gas, a bismuth series was done. Those cases which had symptoms referable to the gall bladder or biliary ducts, were given the Graham test. The excursions of the kidneys were measured on the films. There was a very slight error in the result of measuring the movement on the film but all *x*-rays were taken under the same conditions.

The excursion of the kidneys varied from 4 cm. to 12 cm., the average being 5.5. cm. Fifty-one per cent of the ptosed kidneys occurred on the right side, 11 per cent on the left side and 19 per cent were bilateral; 7 per cent of the cases showed general visceroptosis. These latter cases with general visceroptosis gave a history of ten years or more of pain; while the others gave a history of pain less than three years' duration. Hepatoptosis only occurred in those cases with general visceroptosis. In 40 per cent of the cases there was a long right lobe of the liver. The lobe moved in and out with respiration but not up and down with the kidney. In none of the cases was there an actual enlargement of the liver, 8 of the 55 patients have been proved to have gall bladder disturbance, 5 of these 8 had a history of jaundice, 4 of them had had the gall bladder removed in which were found gallstones, 3 of the remaining 4 had positive Graham tests before nephropexy. One who had a positive Graham test before the nephropexy had a negative Graham test afterward. Dr. Scholl of Los Angeles has called attention to the coexisting gall bladder disturbance in nephroptotic cases. MacLagan and Treves of London report 3 cases in which a diagnosis of gallstones was made but at operation found a ptosed right kidney causing a cystic duct kink.

The spleen was found ptosed only in

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the general visceroptotic individuals. Even in the bilateral renal ptosis cases the spleen did not move abnormally but was sympathetic with the liver.

The rotation of the ptotic kidney has rarely been observed or if so not given enough discussion, 20 per cent of the kidneys were rotated through one or more planes up to 180°. This observation is important in correcting the position of the kidney at operation.

The function of the ptotic kidney is rarely modified, for only 2 of the 55 cases showed any diminution. These 2 cases had a history of long-standing bilateral kidney infection with Bacillus coli. Thirty-three per cent of the kidneys were infected, all with B. coli; most of the pelves which were infected had a slight increase in capacity although only 7 per cent had more than 20 c.c.; 66 per cent had a normal pelvic capacity. All the cases had either a kink, stricture or a tortuosity of the ureter; 80 per cent showed kinks; 50 per cent a tortuosity and 13 per cent stricture. The ureter in all these cases is redundant and must therefore have an abnormal course when the kidney drops. The strictured ureter elongates; hence, in this condition we also find an angulated or a curved course for the ureter. The ureteral strictures occurred in the upper third so that bladder symptoms were only present in those patients who had a urinary infection.

The symptoms of the ptotic kidney are mainly pain, acute and chronic, due mostly to obstruction of the ureter. The emptying time of the kidney pelves has been determined in a few cases only. It is an important observation and should be noted in all cases. In cases so far observed it varied from fifteen to ninety minutes and some longer as they were not followed after this length of time.

In the treatment of renal ptosis the emptying time must be made to fall within a normal period. The ureter is at fault but only secondarily so. Burford and Reilly are performing nephropexies for ureteral kinks. Crabtree suggests nephropexy for ureteral kinks with infections. Not all cases need kidney elevation to obtain drainage. Some respond to passage of a bougie or catheter. Some nephroptotic cases have become free from infection by a few of the usual dilatation and irrigation treatments; others require treatments every six or twelve months. These cases which respond to the conservative treatment have an emptying time of less than twelve minutes. Other cases have such tortuous, kinked and strictured ureters that it is impossible to pass a catheter or bougie up to the kidney pelvis; some have extraureteral adhesions which make kinks with the ptosis and they too do not allow ureteral instruments to pass. Such patients as are incapacitated for work or locomotion are advised to have operative treatment. Since only one-third of the instances here given have been operated upon, the author feels that if there is error in surgical treatment it has been in the favor of conservatism.

The operator should aim to give free drainage to the kidney and ureter by restoring the kidney to its normal position and freeing the ureter of its kinks and strictures. All the operations thus far recommended in the literature either subject the kidney to serious infections, mutilate its capsule or destroy a portion of the parenchyma by puncturing sutures. With the idea of conservation of the functioning portion of the kidney as well as its capsule the author submits the following operative procedure:

Author's Operation: The incision is begun high in the costovertebral angle, continued downward and transversally across halfway between the lower rib and crest of the ilium incising in most cases portions of the external and internal oblique muscles. Approach to the kidney is made through the triangle of Petit. Care is taken to push the twelfth thoracic nerve downward in dividing the transversalis muscle and to leave enough fascia margin, so that when the wound is closed, the nerve will not be caught in the suture. The fatty capsule is opened and the kidney which is usually low in position is easily recognized.

The perirenal fat is all stripped off the kidney which, with its vessels and ureter, is then delivered into the wound. It is important that all adhesions be removed from the upper as well as the lower pole. The ureter which is either tortuous or badly kinked should be made free. The pedicle in all cases is long so that the surgeon should not encounter any difficulty in delivery of the kidney. Special attention should be made concerning the kidney fossa, whether shallow, absent or deep. The liver sometimes is adherent to the posterior abdominal wall so that it is impossible to place the kidney in its bed without freeing up the right lobe. The hand should be inserted under the right lobe of the liver to the diaphragm. When this is done the kidney can be replaced sufficiently high to remove all kinks and most of the tortuosities of the ureter. Lowsley and Kirwin state that the kidney cannot in all cases be placed sufficiently high to obviate the kinks. The reason for this is the elongation of the ureter. The kidney can be made to occupy practically an intrathoracic position with the lower pole lying opposite the last rib. The upper pole should be carried medially and the lower pole outward to give dependent drainage to the lower calyx.

With the kidney held in this position a series of interrupted mattress chromic No. 0 sutures are placed through the perirenal fascia and peritoneum to the quadratus muscle. Perirenal fascia is always excessive so that it can be easily approximated. Precautions must be taken not to include the bowel medially. The first stitch should be placed about 1 cm. from the ureter and as high up as possible on the quadratus muscle posteriorly. Care should always be taken not to include any of the nerves in these sutures of chromic gut. A series of five to eight sutures are necessary to close this aperture. This forms a basket-sling for the kidney so that it is impossible for the organ to descend. This row of sutures is now enforced by bringing up all the extraperitoneal fat and suturing it with two or three mattress sutures to the quadratus muscle below the other line of sutures. This acts as a support and fills the space previously occupied by the kidney. The wound is then closed in layers with No. 2 plain catgut and the skin with interrupted silk without drainage.

The patient is kept flat in bed for sixteen days, allowed out of bed on the eighteenth day and home on the twenty-first or twenty-second day. None of the cases developed complications and all but one were completely relieved of the symptoms. The one failure was not the fault of the operation but an error in application as the kidney pelvis had a capacity of 40 c.c., was infected and the ureter badly strictured.

All the cases have had follow-up cystoscopies either at the time of discharge, at one year or later. One has had a cystoscopy with urograms after a pregnancy and the kidney found to be in the same position as it was placed at operation. Six of the 7 cases that had kidney infection previous to operation cleared afterward. Several of the cases with strictured ureter had dilatations following the nephropexy and remain perfectly well.

CONCLUSIONS

1. Visceroptosis is rare with nephroptosis.
2. Gall bladder disease is not an uncommon complication of nephroptosis.
3. Hepatoptosis is apparent and not real, due to a long Riedel's lobe.
4. Ureteral lesions occur in the upper third.
5. Kinks are secondary to ptosis.
6. Rotation of the kidney is common.
7. Renal infections occur in 33 per cent.
8. Some nephroptotic cases respond to conservative treatment.
9. A new and successful operation has been devised which does not in any way injure the kidney or its capsule and which utilizes all the natural supporting structures and places the kidney in an anatomically correct position.

[For discussion of this paper see p. 229 and for bibliography see author's reprints.]

TUBERCULOSIS OF THE KIDNEY

A CRITICAL REVIEW BASED ON A SERIES OF TWO-HUNDRED TWENTY-ONE CASES*

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THIS paper is based upon a series of 221 cases that have been under my personal observation. It does not represent all the cases of renal tuberculosis that have been seen, but only those with records of sufficient data which made it worth while to study them and to include them in a presentation of this kind.

In some of the early cases certain data are completely absent. This is due to the fact that the present-day methods of examination were not in use at the time these early cases were seen; for example, in the early cases pyelograms were not made and later on they were made at only very rare intervals. Likewise routine roentgen-ray examinations of the urinary tract as well as of the chest were not carried out, whereas today this is done as a routine procedure in all cases of tuberculosis of the kidney. Other data, however, were present in sufficient amount to make the cases available for study.

FREQUENCY

Because there is a gradual and progressive reduction in the incidence of pulmonary and glandular tuberculosis, it is but natural to expect that there should be a corresponding diminution in the incidence of renal tuberculosis; no doubt in the future this will come to pass. However, present-day statistics, according to Wildbolz, showed that in a series of 2345 autopsies performed in six years in the Pathological Institute in Berne, Switzerland, tuberculous foci in the kidney were found present in 5.3 per cent. The lungs in this same group of cases showed tuberculosis in 20.7 per cent. A somewhat different aspect of the frequency of renal tuberculosis is obtained from the statistics of Braasch who reported a series of 532 persons operated upon for renal tuberculosis; during this period 85,000 patients were operated upon and he stated that the incidence of surgical renal tuberculosis may be estimated as 0.6 per cent. The variation in these statistics, no doubt, is due to the fact that in one group of cases the disease process was far advanced and probably resulted in the death of the patient, whereas in the other, a clinical group, the diagnosis was made early.

HISTORY

One cannot too often stress the importance of a carefully obtained history in any surgical condition. This applies particularly to cases of renal tuberculosis since many times one is amply rewarded for his trouble. In taking a history one may receive his reward from statements that immediately focus one's attention on the possibility that the patient's present complaint may be tuberculous in origin and may be the sequence, directly or indirectly, of a previous operation for some tuberculous disease elsewhere in the body. One of the amazing things brought out in this study is the fact that in this series of 221 cases there were 43.5 per cent in which the patients gave a history of having had some sort of a previous operation. Forty-two of these cases, or 47.7 per cent, had had an operation for a tuberculous disease.

For the purposes of discussion these previous operations may be considered under the following headings: (1) operations for tuberculous lesions of the genito-urinary tract; (2) operations for tuberculous lesions outside the genito-urinary tract; (3) operations for the relief of symptoms complained of and for which no

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relief was obtained from said operations; (4) operations without relation to the present trouble.

Group I. In this group of 28 cases the largest number had been operated on for genital tuberculosis. One half of this total, or 14 cases, had had a previous castration and one had a double castration. The fallacy of performing a castration in tuberculosis of the genital tract needs no discussion at this time. I think we are all in accord with the fundamental principle that tuberculosis of the epididymis is best treated by epididymectomy and not by castration.

TABLE I

OPERATIONS FOR TUBERCULOUS LESIONS OF GENITO-URINARY TRACT

	No. Cases
Castration	14
Epididymectomy	6
Epididymectomy and appendectomy	1
Double castration	1
Previous nephrectomy	2
Previous kidney drainage	2
Decapsulation of the kidney	1
Kidney drained and psoas abscess drained	1
	28

Group II. In this group there are 14 cases. Thirteen cases gave a history of a previous operation for a very obvious tuberculous lesion outside the genitourinary tract. In one case the nature of the operation could not be definitely determined. It is undoubtedly of value to elicit, if possible, from the patient's physician or from the hospital at which the patient was operated upon, information regarding previous operations, unless, of course, one feels sure from the patient's statements and the results obtained at the physical examination, that the evidence is convincing enough without further investigation. Lesions of the bones and joints predominate in this group.

TABLE II

OPERATIONS FOR TUBERCULOUS LESIONS OUTSIDE THE GENITOURINARY TRACT

	No. Cases
Tuberculous glands of the neck	2
Tuberculous glands of the groin	2
Fistula in ano	1
Fistula in ano and osteomyelitis of hip	1
Psoas abscess	1
Perirectal abscess	1
Osteomyelitis of the elbow	2
Tuberculosis of the knee	1
Tuberculosis of the shoulder	1
Tuberculosis of the ulna	1
Operation on hip (T. B.?)	1
	14

Group III. In this group there were 26 patients who consulted their physicians because of various urinary symptoms. Their urinary symptoms, their cause and significance, were not appreciated and the patients were subjected to a surgical procedure without obtaining the desired relief. As one might expect, appendectomy heads the list and in this group there were 10 patients who had had their appendices removed. There were more appendices removed than have been listed in this series, as the cases of perineal repair also had had an appendectomy. There were 4 genitourinary operations performed in this group, 2 suprapubic cystotomies and these were done for the specific purpose of bladder drainage, 1 external urethrotomy, and 1 case was allegedly operated upon for a stone in the bladder but the patient never saw the stone. These patients obtained no relief from these operations.

TABLE III

OPERATIONS FOR RELIEF OF SYMPTOMS WITHOUT OBTAINING RELIEF

	No. Cases
Appendectomy	10
Suprapubic cystotomy	2
External urethrotomy	1
Stone in bladder?	1
Perineal repair	4
Exploratory laparotomy	3
Fibroids	1
Hemorrhoids	1
Curettement	1
Salpingectomy and oophorectomy	2
	26

Group IV. In this group the subject of a previous operation is one of incident only, since the operations, as far as it was possible to say, had no relation to the patient's present trouble. Tonsillectomy heads this group.

TABLE IV

OPERATIONS WITHOUT RELATION TO THE PRESENT TROUBLE

	No. Cases
Tonsillectomy	17
Gallstones	2
Hemorrhoids	2
Hyperthyroidism	1
Mastoid	1
Nasal	1
Carcinoma of breast and (pelvic lavage?)	1
Hernia	2
Abscess (nature?)	1
	28

THE INCIDENCE OF AGE

It is generally believed that renal tuberculosis is primarily a disease of adult life and a review of the age incidence in this series bears out this general view. The largest number of cases occurring in any one decade was 73, the ages ranging between twenty and twenty-nine. More than one-half of the cases, or 56 per cent, occurred between twenty and thirty-nine years. The youngest patient was a female, seven years of age, and the oldest was a female, sixty-nine years old, and between these two limits the following distribution of ages is to be noted.

TABLE V

AGES

Years	No. Cases
7	1
10 to 19	23
20 to 29	73
30 to 39	51
40 to 49	40
50 to 59	21
60 to 69	5
Not stated	7
	221
Youngest, female	7 years
Oldest, female	69 years

It would appear that renal tuberculosis in infancy and childhood is uncommon. In this series only 1 case occurred before ten years of age. No doubt, with the widespread interest in urology in children, some of the cases of so-called chronic pyuria and perhaps some of the cases of so-called chronic pyelitis may ultimately prove to be due to renal tuberculosis.

Recent autopsy statistics have given us a somewhat different viewpoint; thus, Rilliet and Barthez demonstrated renal tuberculosis in 15.7 per cent of 312 autopsies done on tuberculous children, and in the Pathological Institute in Berne, in a series of 126 autopsies on tuberculous children, 13 cases, or 10 per cent, of renal tuberculosis were found.

SEX

The question as to which of the two sexes is the more frequently afflicted with this disease seems at this time to be in a state of uncertainty. The figures on this subject will depend in part upon the type of practice carried out by the individual who reports the cases; some urologists operate upon and see a preponderance of males, hence, they naturally would report a series in which males predominate. On the other hand, a gynecologist, reporting a series of cases, would naturally report more women.

In this series there were:

	No. Cases	Per Cent
Males	123	55.6
Females	98	44.3

Wildbolz, in his series of 245 cases which included both operated and non-operative cases, found practically no difference in the sexes. The statistics of Braasch, on the other hand, showed approximately twice as many males as females, the males being 63.5 per cent and the females, 36.5 per cent.

SIDES INVOLVED

Much more important than the question of age and sex incidence is the question of whether or not in a given case one is dealing with a unilateral or a bilateral disease process. After all, it makes very little difference whether the patient has the tuberculosis on his right or left side, other than for statistical or academic proof or reasons. Much more important, of course, is the question of whether the lesion is unilateral or bilateral. This assumes great importance from the stand-

point of treatment and raises the question of the surgical removal of one of the two diseased kidneys in cases in which the disease process is bilateral.

Even after a very careful, painstaking examination that shows one kidney to be normal, because of a clear urine that is free of pus and negative for tubercle bacilli, there always exists the possibility that one has failed to find tubercle bacilli, or again, the possibility that in the particular kidney a focus of tuberculosis exists that has not or does not communicate with the pelvis, hence, cannot be detected. In one of our cases this point was taken up in great detail and a most careful, painstaking search for tubercle bacilli was made in the urine from the opposite or healthy kidney. Repeated guinea pig tests were made but they were all negative. The patient, a boy of eighteen, died three months after the operation of tuberculous meningitis and at autopsy a very small tuberculous lesion was found in the remaining kidney.

The importance of this point is apparent both from the standpoint of prognosis and postoperative duration of life and also has a bearing on the value and the results of surgical treatment.

The seriousness of the responsibility of determining whether or not the opposite kidney is free of tuberculosis is a question that I always enter into with a feeling of grave responsibility, particularly since my experience in the case just mentioned. I always make it a rule to regard the opposite kidney with suspicion until the presence in it of a tuberculous focus can be positively excluded.

When the laboratory report shows one or two tubercle bacilli, in the urine from the supposedly normal side, and the urine contains only a few leucocytes, the problem of evaluating these findings is exceedingly serious. The question of regurgitation of infected bladder urine alongside the catheter has been discussed by Dr. Beer and the question of dragging infected urine up from the bladder by means of the catheter has been emphasized. The possibility of dragging up organisms by the catheter can be negatived by plugging the ends of the ureteral catheters with large bank pins, a procedure carried out in many clinics.

Formerly, in order to determine this point, a very careful study of renal function was advised and carried out. Unfortunately, just in this group of cases the lesion is small and the destruction of kidney tissue minimal, so that there is not much renal impairment, therefore not much difference in function.

It is just in this group of cases that I have felt justified in making a pyelogram to determine whether or not an early lesion is present. With this sort of problem before us I think an unusually careful reading of a pyelogram will clear up this point, and I believe pyelography in this group of cases is of much more value than is a study of renal function. It is my impression that one of the very important problems in renal tuberculosis is the determination of this point, and it is my personal conviction that, with more time and study devoted to this particular problem, the number of bilateral cases will increase in number in any given series.

The same problem confronts one in suspected cases of unilateral renal tuberculosis in which one or two tubercle bacilli are found in a clear urine or in urine that contains only a few leucocytes.

Of one thing we can be certain and that is that in this group of cases there is never any hurry to operate; hence, ample time is at hand for careful and, if necessary, repeated clinical investigation. The course of the disease is slow and should any doubt exist in my own mind, I wait for the results of the first guinea pig inoculation, made at the time of the first cystoscopy. If the first examination is negative and if one has reason to question the condition of the kidney to remain, I never hesitate to subject the patient again to a second complete urological study; that is, another cystoscopic examination is done, the catheter-

ized kidney specimens are again most carefully examined for tubercle bacilli, another set of guinea pigs are inoculated and perhaps another set of pyelograms made. I await the result of the second set of guinea pig inoculations. There have been instances in which even a third complete urological survey was done, but instances are very rare.

This, of course, does not apply to the cases in which one is dealing with a frank unilateral renal tuberculosis and cases in which there is no question about the opposite side.

Much has been said and written about the early recognition of renal tuberculosis and the institution of early surgical treatment. With this view I am wholly in accord. Nevertheless, in spite of this dictum, I would rather wait several months so as to check up and be sure, where doubt may exist, rather than remove a normal kidney. Much evidence can be advanced for and against this delay, but I do not know of a single instance in my own experience in which delay led to a bad result or caused regret.

In this series of cases there were 41 bilateral cases of renal tuberculosis, or, in other words, a percentage of 19.3. Even these figures may be in error in that they are too low, because, as already mentioned, it is relatively easy to miss a small focus that may be present at the time the patient is under examination. These figures, therefore, represent a minimum incidence and not a maximum one.

With the importance of accurate diagnosis before us, associated with the development of new culture methods for growing tubercle bacilli, as well as a renewed interest in developing better technic for showing the organism in smears, coupled with the refinements in roentgen-ray diagnosis of the various types of calcification seen in the renal area and supplemented with the additional help of pyelography and, finally, with a keen appreciation of the seriousness of the subject at hand in each given case, the result, I believe, will be an increasing number of cases of bilateral renal tuberculosis.

Wildbolz in his series of 245 cases found bilateral renal tuberculosis in 12 per cent of the cases. Brongersma reported a series in which the lesion was bilateral in 14 per cent and Braasch found 16 bilateral cases in his series of 532 cases, or 3 per cent.

In this series there were 14 cases in which the side of involvement was not determined. By way of explanation may I state that this occurred in cases in which there was extensive tuberculosis of the bladder so that cystoscopic examination was exceedingly difficult; there were cases in which the ureters were not seen, cases in which only one side was catheterized and cases in which patients refused a complete urological survey and left before the examination was finished and cases that were proved elsewhere. This point will be considered in detail further on in this paper.

The difference between the frequency on the one side or the other is so slight as to make no practical difference. It is generally assumed that the right side, because of its greater mobility, is more frequently involved than is the left side, but the difference is so slight as to be of no great importance in the diagnosis or differential diagnosis.

Not only is it important not to overlook a bilateral case and, perhaps, perform an unnecessary surgical operation, but the opposite condition may exist in which the patient has been erroneously diagnosed as a case of bilateral renal tuberculosis. By this diagnosis he or she may be deprived of surgical treatment. As a matter of fact nephrectomy is the only therapeutic agent at hand for the patient.

THE PRESENCE OF PULMONARY TUBERCULOSIS

At the present time each case of renal tuberculosis is subjected to a complete physical examination and this includes, of course, a roentgen-ray examination not

only of the genitourinary tract but of the chest as well. This procedure is now being carried out as a routine, whereas, formerly, the physical examination only was done and was not checked up by means of the roentgen ray. These two methods of examination should be supplemental.

The roentgen-ray examination may often show the presence of an old healed lesion, or, may perhaps demonstrate a very small lesion, both of which may be missed following a physical examination. As a routine procedure I carry out both roentgen-ray and physical examinations, using one as a check against the other.

The records of 180 cases are available and they showed that there was evidence of involvement of the lungs in 35.5 per cent of the cases.

The old or healed cases had no effect upon the operative mortality. The cases in which active tuberculosis was found were carefully considered from the standpoint of the choice of an anesthetic.

THE PRESENCE OF TUBERCULOSIS IN OTHER ORGANS

The next largest group that showed the presence of coexisting tuberculous disease in organs other than the kidneys and lungs were the cases in which the genital tract in the male was affected by tuberculosis. As is well known, tuberculosis in the genital tract of the female is uncommon. In this series there were 123 males. The records show that 39 of them had involvement of the genital tract, that is, prostate and vesicles, and in 26 of these cases there was an additional involvement of the epididymis.

DURATION OF SYMPTOMS

Tuberculosis of the kidney is, of course, no exception to the rule that the best ultimate results are obtained in early cases. I think one is justified in stating that the largest number of cases are unilateral *early* in the course of the disease. Both autopsy and clinical statistics show that late in the course of the disease the percentage of bilateral cases is very high. Furthermore, it is almost universally admitted that the best functional results, as far as the bladder is concerned, are obtained in cases in which there is a very slight or no involvement of the bladder. Nothing is quite so discouraging to both the patient and the physician as failure of an operation to relieve the symptoms that make life almost unbearable. It is just this type of case with its persistent great suffering that makes one feel justified in making a strong plea for the early recognition of renal tuberculosis and for instituting surgical treatment before there is much if any involvement of the bladder.

In 121 cases the symptoms had been present for one year or in 54.7 per cent. The next largest number had symptoms for two years and there were 33 in this group. Therefore, in 154 cases, or in 69.6 per cent of these cases symptoms had been present for two years before they came under observation and were subjected to correct diagnosis and treatment. The longest duration of symptoms was in the case of a female, aged fifty-eight, and they had been present for twenty-six years.

The amount of impairment of bladder function is of course in direct ratio to the duration of the disease and the persistence of the bladder symptoms after the operation is likewise due to the length of time that it has existed. Therefore, in order to

Table VI

DURATION OF SYMPTOMS

Years	Cases
1	121
2	33
3	11
4	7
5	12
6	7
7	2
8	2
9	1
10	2
11	1
12	2
15	4
19	1
26	1
Not stated	14
	221

have a good functional result, treatment must be carried out before there is much destruction of bladder function.

SYMPTOMS

Frequency of urination is one of the most constantly present symptoms that, as a rule, manifests itself early in the course of the disease and often persists long after the patient has been operated upon and the kidney removed and the bladder infection has cleared up. In this series frequency of urination was present in 184 cases or 83.2 per cent. Nocturia was present in 166 cases. The following table gives the symptoms in their order of frequency.

Table VII

	Cases
Frequency	184
Nocturia	166
Hematuria	107
Pain on urination	98
Pain in back	88
Loss of weight	65
Fever	41
Chills	27
Nausea	22
Vomiting	22
Renal colic	15
Incontinence	12

URINALYSIS

It is generally believed that in cases of renal tuberculosis abnormal elements are present in the urine and of these elements pus in the urine heads the list. In this series pus was present in 201 cases, or 90.9 per cent. Following is the table of urinalysis:

Table VIII

URINALYSIS

	Cases
Leucocytes	201
Albumin	171
Red blood cells	112
Casts	24
Not stated	15

One must not lose sight of the fact, however, that the patient may present himself with a clear urine and that because of this fact the possibility of urinary tuberculosis may be overlooked.

THE PRESENCE OF TUBERCLE BACILLI IN THE URINE

In this series the usual ordinary routine examinations for tubercle bacilli were carried out. In 194 cases, or 87.7 per cent, the presence of tubercle bacilli was demonstrated either upon smear or by guinea pig inoculation, or both. Of these 194 cases, smears made from bladder urine were negative in 13 cases in which the guinea pigs inoculated with the bladder urine were positive; smears made from the right kidney were negative and guinea pigs inoculated with urine from the right side were positive in 15 cases; smears of urine from the left side were negative, while guinea pigs inoculated from the left side were positive in 10 cases; hence, in those cases with negative smears, the positive guinea pig inoculations were of great additional aids in helping to make the diagnosis.

	Cases	Per Cent
Diagnosis made by demonstrating tubercle bacilli in the urine either upon smear or by guinea-pig inoculation	194	87.7
Diagnosis made without demonstrating tubercle bacilli in the urine	27	12.3

DIAGNOSIS MADE WITHOUT DEMONSTRATING TUBERCLE BACILLI IN THE URINE

In 27 cases in this series the diagnosis of renal tuberculosis was made without demonstrating tubercle bacilli either in the urine or in the guinea pigs, that is, the diagnosis was made without bacteriological proof. These cases for study may be divided into two groups: the group in which the diagnosis was made by means of the *x*-ray findings in the flat plate and the group in which the diagnosis was made by the cystoscopic examination either with or without ureteral catheterization.

Group 1: In this group the diagnosis was made from the flat plate in 7 cases. These cases were further divided into two groups, those in which the *x*-ray picture was that of a so-called healed tuberculosis, this *x*-ray being typical and hardly to be

confused with any other roentgen-ray finding. In the second group the findings of the *x*-ray were in the form of small irregular areas of calcification, so frequently found in routine *x*-ray examinations that doubtless they are familiar to you. In a few of these cases, not only were these areas of calcification found in the renal areas but occasionally the areas of calcification were found outlining the course of the ureter. While the latter finding is rare, it is none the less a striking one that can hardly be confused in differential diagnosis.

Group II: In the remaining 20 cases the diagnosis was a clinical one and was based upon the following data: the history of a long-standing bladder disturbance, often aggravated by local treatment and the presence of a persisting pyuria that failed to respond to the usual internal treatment, led us to regard the patient as suspicious. A cystoscopic examination revealed the well-known findings of bladder tuberculosis such as the presence of a limited bladder capacity, the exceedingly painful cystoscopic examination, the presence of areas of ulceration and tubercle formation, changes about one ureteral orifice whereas the opposite was normal, the ureteral catheter often meeting an obstruction on the suspected side, and the presence of clear urine on one side and pus on the other. In other words, in this group the diagnosis was purely clinical *but was verified by operation or autopsy*.

In several instances the bladder tuberculosis was so extensive and so far advanced that cystoscopic examination and ureteral catheterization were decidedly unsatisfactory; hence, outside the fact that the diagnosis of tuberculosis of the bladder was made, no study of the kidneys was possible.

In several cases we resorted to the use of cystography as an aid: this showed the presence of reflux up the ureter with a resulting set of pyelograms that demonstrated bilateral tuberculosis. Reflux or regurgitation, as is well known, is not an uncommon occurrence. Cystography is of great value in just this type of case.

In 2 cases of this series an exploratory operation was done. The exploratory operation was made in each case only after repeated attempts to obtain the necessary information in some other way which, because of the condition, rendered the examination nil. In one case the diseased side was catheterized and the exploratory operation was performed to demonstrate the presence of a normal kidney. I know that this method is rarely, if ever, justified. Furthermore, I also know that small tuberculous lesions may be readily overlooked in this way. That they were not overlooked in this case, however, is proved by the fact that this patient is alive and well fourteen years after her nephrectomy.

The other case of exploratory operation revealed the presence of bilateral disease far advanced.

It should be borne in mind that both these patients had had symptoms for many years and were the victims of the seat of advanced bladder tuberculosis. Furthermore, these cases were among the early ones and occurred long before the routine use of sacral anesthesia and, finally, of course, this is not to be construed as my being in favor of exploratory operation in lieu of modern urological study.

Some of these early cases contain records of only a few negative examinations for tubercle bacilli and quite a number only one record. It is to be noted that most of them occurred early in this series before repeated examinations were insisted upon and also in cases on services of other men who stopped looking for tuberculosis just as soon as the cystoscopic diagnosis was made. Some of the cases were in for a day or two and examinations were not made after the first negative reports.

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DISCUSSION OF PAPERS BY DRS. DEMING AND KRETSCHMER

Dr. Edward L. Keyes: I was particularly interested in Dr. Deming's comments on rotation of a mobile kidney. I think one gets from his paper a clear idea of the importance of kidney displacement in causing pain by rotation, and I quite agree with what he says on the subject. It is well known that gall bladder disease occasionally occurs in conjunction with descent of the kidney.

But I note that he failed to mention lumbago. I find that pain in the lumbar muscles is a confusing element in the diagnosis of pain due to renal disease. I recently saw a patient who had undergone a number of dilatations of the right ureter, who had a mobile kidney and was said to have a stricture. It was also claimed that there had been infection, which at the time she was first seen by me had cleared up. She had been relieved of her most severe symptoms, but was still complaining of pain, for which her doctor proposed to continue the dilatations. But when I saw her the pain seemed exclusively in the erector spinae muscle. The urine was free from pus; there were no bacteria in it. The pain was ultimately relieved by massage.

Dr. Deming did not make it clear to me what value he attaches to kinks in the redundant ureter. I am inclined to consider them of very little importance. He mentioned a number of cases relieved by dilatation of strictures, but in which the kinks persisted. I suppose it is generally recognized that kinks, as such, along the upper ureter frequently fail to cause obstruction. I do not, of course, include stricture at the upper end of the ureter. It has been my observation that such strictures require resection or some other form of operative relief. I should like to know Dr. Deming's opinion on that point.

I should also like to hear what he thinks of denervation of the kidney, a subject not included in his paper. At a recent meeting of the Pennsylvania State Society, Dr. Hess read a paper dealing with a dozen cases, one-half relieved of pain by denervation. I confess that I have only tried it tentatively, and have no views on the subject.

As far as I am concerned, Dr. Deming's operation is a new one. I have certainly tried, as many of us have, to patch up the fascia about a kidney and make a bed. I was chiefly led to do so by observations of my father, who used to do a quite successful nephropexy by stuffing wads of gauze underneath and letting the kidney lie on it, gradually removing the gauze and leaving a large scar. The patient remained in bed quite a while, and the same result was obtained as with this new operation, generally speaking. Briefly, I want to compliment Dr. Deming on what to me is the greatest triumph of this operation, i.e., not so much that the kidney is replaced in a very high position, but that it remains fixed and so placed that the lower calyx is drained.

Dr. Walter G. Schulte (Salt Lake City): Dr. Kretschmer apparently sees more early and more unilateral cases of renal tuberculosis than we see in Salt Lake City. Most of our cases are referred to us later, when they are bilateral and surgery is not as important as general treatment for tuberculosis. With sunshine and fresh air much can be done in these cases. I have several that are doing very nicely after five to seven years.

I am going to try Dr. Deming's method of anchoring the kidney. I have had very good results in a number of cases that I have suspended because of persistent pain due to faulty drainage.

Dr. Benjamin S. Barringer: The papers of this evening recall to mind that it was Dr. Deming who recently told us how to conserve kidney tissue. I have followed his method of keeping the sutures close to the edge of the kidney and feel, as he outlined last year, that very little parenchyma is destroyed in this way. Now he comes along with another new and very practical operation. I am not exactly clear as to the indications for this operation, but I presume they are pain and impairment of kidney function.

The only really new impulse I have received in the last year on the subject of kidney surgery in tuberculosis was on hearing Dr. Jeck's paper on the administration of spinal anesthesia for these operations. I have since used this method of anesthesia, and believe it is a big step in advance. I would like to know if Dr. Kretschmer has employed it. I recently had a case of kyphosis, where there was no space between the ribs and the pelvis, a tuberculous kidney and a poor heart. The patient would have been a poor risk for a general anesthetic because of the kyphosis alone. A modification of Pitkin's method was used. I took the kidney and the rib out, and feel sure she

would not have done as well with a general anesthetic. I would therefore like to know Dr. Kretschmer's views on the subject.

Dr. Alfred T. Osgood: Although I am especially interested in Dr. Deming's operation it has been my experience that nephroptosis is a condition very seldom requiring surgery. It seems that we are finding increasingly few cases in which we are compelled to operate. However, Dr. Deming's careful study, and the way in which the cases were selected, has proved very instructive to me.

Dr. A. R. Stevens: I shall touch briefly on just one or two points in each of these papers.

Apparently Dr. Deming has devised a means of holding up a ptosed kidney without cutting into the kidney or taking sutures through it. This seems to me a step in advance over the ordinary methods if the results are permanent. I wish, however, that he would tell us whether he has made pyelograms in any of his cases as much as two years after this operation.

In the pyelograms which he showed, all of the renal pelves showed dilatation; and as I recall them, this dilatation extended well down into the corresponding ureters. He said that in about two-thirds of these he was able to make the patients comfortable by ureteral dilatation. I was just wondering how much stress he places on this method of treatment, as many urologists would look for a low ureteral obstruction in these cases. In the roentgenograms of kidneys which had been replaced in the proper position, there still remains, as far as I can make out, quite as marked dilatation of both kidney pelves and ureters.

Dr. Kretschmer spoke of "excluding a tuberculous focus in the other kidney." I do not see how he can. It seems to me that if we have tuberculosis in one kidney, there is always the possibility of its presence in the other. We can only prove a tuberculous focus which has broken into the renal pelvis, and the possibility of undemonstrable tuberculosis in the so-called good kidney should always be borne in mind, as well as tuberculosis that cannot be proved elsewhere in the body, in advising the individual as to his hygiene and future mode of life.

In those cases where we cannot find the ureter orifices and so cannot catheterize the ureters, there arises the question whether it is not better to do a suprapubic cystotomy, catheterize the ureters and so get direct facts, rather than explore both kidneys and take out the one which merely appears to be the worse.

Dr. Edwin Beer: Dr. Kretschmer has expressed views very similar to those I set forth last Spring when Dr. Medlar discussed the subject of renal tuberculosis before the Section on Genito-Urinary Surgery of the New York Academy of Medicine.

As to Dr. Deming's presentation: My experience with nephropexies is limited, as I feel the indications for this operation are rare. If there is pain and a dilated pelvis with delayed emptying while the patient is in an upright position, it is my opinion that a plastic operation should be performed on this pelvis, with an excision of the redundant wall and a firm fixation of the decapsulated kidney. In many of these cases the ureter is kinked high up in its course by periureteral fixation adhesions. This should be freed at the same time that the kidney is sewed in place. The hammock operations of the past, which have been repeatedly proposed, simulate very closely what Dr. Deming has presented tonight, and I do not believe that fixation of the kidney with extraperitoneal extrarenal supports established with chromic gut sutures will permanently fix the kidney. It is my opinion that a decapsulation and fixation through the cortex and capsule of the kidney with a cigarette drain below the lower pole of the organ will not only be more successful but will obliterate with scar tissue the pocket below the kidney in the perirenal space. A series of late pyelograms following Dr. Deming's modification of the hammock procedure would be valuable testimony in favor of his method of fixation.

As far as the renal tuberculosis problem is concerned, all of us are very much interested in it. Dr. Schulte has said that it is usually bilateral. Medlar and Harris have made the same statement. Experience, however, shows that surgical tuberculosis is unilateral in the great majority of cases, and even at autopsy Rafin reports that over 50 per cent are still unilateral. Dr. Schulte may see only late cases which go on to a fatal termination, but Drs. Medlar and Harris claim that the second kidney gets well following the removal or even without the removal of the one tuberculous organ. Mistakes in interpretation of cystoscopic findings, to my mind, undoubtedly underlie such strange interpretations. Rollier apparently has fallen into the same type of error, and has thought that he has cured bilateral renal tuberculosis by heliotherapy. In most of these cases it is very easy to make a mistake in the diagnosis of bilateral disease when the

disease is definitely unilateral. On one side pus and tubercle bacilli are found in the smear; on the other side the urine in the guinea pig test is positive, the smear usually negative, and a few white cells are found in the centrifuged urine. The significance of the positive guinea pig test on the second side is open to two interpretations: One, that it is a gross contamination from the catheter or by reflux, or due to excretory bacilluria; the other, that it is actually indicative of tuberculosis in the second organ. We have found in studying these cases that 18 per cent of the second kidneys showed positive guinea pig reaction, and Braasch found exactly the same percentage in his series. Still, following nephrectomy of a definitely diseased organ, patients have remained well in a great majority of cases, and subsequent guinea pig studies were negative. In view of what we know about the ease with which specimens can be contaminated unless a most rigid technic is carried out (and even in these circumstances difficulties are encountered), and considering the fact that we know that no definite renal tuberculosis case has been proved clinically as having gotten well, it is fair to assume that Harris, Medlar and Rollier are mistaken, and that nephrectomy of the more diseased organ is not leading to the cure of the second mildly diseased organ. A preponderance of these cases undoubtedly is incorrectly diagnosed, the tuberculosis which leads to the contamination of the urine from the healthy kidney being present either in the one frankly tuberculous kidney or in the genital tract.

Teachings such as these by Medlar, Harris and Rollier, and others, will undoubtedly lead to gross neglect of the patients suffering from renal tuberculosis. A recent paper by Harris in the *British Journal of Surgery* is worth reading, as its logic seems at first blush irrefutable but, on more careful study, most fallacious. He finds in the guinea pig test of the urine of bone and joint cases a high percentage of positive tuberculous bacilluria, whereas frank renal tuberculosis incidence in tuberculous bone and joint cases is less than 1 per cent. From this he concludes that the difference between his positive findings and normal incidences represents the cases that get well spontaneously. To convince any urologist of this, the cystoscopic findings and the ureter specimen examinations would have to be reported in each individual case and the technic of the cystoscopist would have to be above all reproach. Moreover, the follow-up would have to be over a number of years, and the genital tract would have to be proved non-tuberculous, which is an almost impossible desideratum. Unfortunately, all of Harris' adult cases were males; if he had studied females, I venture to assert that he would have introduced less confusion into this whole domain. Such publications upset the internist, and are harmful to the patient who is suffering from renal tuberculosis.

Dr. Nathaniel P. Rathbun: With reference to Dr. Deming's presentation, I think some of us remember that twenty-five or thirty years ago there was a tendency to hang up ptosed kidneys, and another period when they gave it up in disgust. Another paper this year on this subject was that of Dr. J. D. Barney, of Boston, who reported many cases. The outstanding point is that these cases must be very carefully selected. Dr. Deming perhaps operates on these cases rather more frequently than I do.

One very important point he has made is that we must be very careful, where there is a ptosed kidney with pain in the side, that we do not overlook some other pathology. He mentions a considerable series relieved without operation. Many cases where the kidney moves all over the abdomen give no symptoms. Also many have kinks and twisted ureters, without symptoms. I think one notable point is that the symptoms complained of are not always due to ptosis. Dr. Deming's operation is very ingenious, indeed. Like Dr. Keyes, I have done such an operation informally, where I tucked the kidney up with any tissue available. I do the old Edebohls operation, plus this little tucking-in process. Dr. Garrity said some years ago that about the best method of doing a nephropexy was to make the usual incision, deliver the kidney, "paw around a bit," replace the kidney and put the patient to bed in the Trendelenburg posture. I am not sure but that he was right.

I was glad to note that Dr. Kretschmer does pyelograms in some of his cases. I do it in all of mine, as I believe it is valuable along the lines Dr. Kretschmer has pointed out. I have had no ill effects, in spite of adverse reports from various clinics, and believe that their difficulties are due to the use of too large catheters, rough handling, etc.

A number of years ago I had a case similar to Israel's famous bifid ureter case. There was a tuberculous lesion around the ureter. Catheterization of this ureter showed crystal-clear urine with no pus or tubercle bacilli. Catheter-

ization on another occasion of this same ureter showed much pus and many tubercle bacilli. At operation we found a bifid ureter with tuberculosis in that segment of the kidney drained by one of the ureters. A pyelogram would have quickly solved this apparent mystery.

There are two classes of cases where diagnosis is extremely difficult. One is that of ulceration in the bladder, tubercle bacilli in the bladder urine, nothing suggestive about either ureter orifice, and no tubercle bacilli from either side, yet where we feel sure there is renal tuberculosis on one side. In such cases I agree with Dr. Kretschmer that we are safe in waiting. Too early operation in renal tuberculosis sometimes does not show as good a result as when we wait a little longer. I do not approve of waiting until we have a marked contraction of the bladder or anything of that sort, but at the same time in early cases there is no indication for hurried operation.

Another type difficult to diagnose is where the bladder is so filled with extensive ulceration that we cannot catheterize either ureter and cannot get roentgenographic evidence that locates the lesion. Ten or twelve years ago I had the temerity to present before one of our national societies the suggestion of opening the bladder and arriving at a diagnosis by catheterizing the ureters, making the point that we could thus get relief from symptoms and give the patient a certain amount of bladder rest which would prepare him for a later nephrectomy, and that following the operation the fistula would probably heal and if it did not heal, the patient probably had the type of bladder with which he would be just as well off with a permanent fistula. I was sat upon so hard that I have never ventured to suggest this again. But I am not sure, nevertheless, but that it might be worthy of consideration.

Dr. J. Sturdivant Read: I would like to emphasize that a ptosed kidney is not always a pathological kidney. A freely movable kidney which does not give symptoms needs no surgery. Frequently symptoms which are thought to be due to movement will entirely disappear for many months after dilatation of ureters. If symptoms persist, then it is right to replace the organ by operation. If the infection in the pelvis of the kidney is cured, many types of operation will hold the kidney in place for at least two years. Dr. Deming's sound and brilliant presentation of a better method of fixation offers hope of a greater percentage of permanent cures.

Dr. Kretschmer has given us a paper replete with keen clinical observations from which he has made deductions helpful to us in the difficult art of diagnosis of obscure tuberculous lesions in the kidneys. In making a diagnosis of renal tuberculosis by means of the roentgen ray, it is well to remember that shadows of calcium salts can be thrown by extrarenal pathology. They are due to inflammatory products, and the condition is not at all peculiar to tuberculosis. We are therefore thrown back on making a diagnosis on delayed function of one kidney, pus, and the presence of tubercle bacilli. If one or two of these findings occur in conjunction with shadows suggestive of calcium deposits in the kidney, then the radiogram is a piece of evidence often of great value.

Dr. Daniel A. Sinclair: In considering these papers and the discussion which has followed them, it seems to me that the finding of pus on one side, with tubercle bacilli and the usual bladder symptoms which accompany tuberculosis of the kidney, with a clear urine (even though it does contain a few leucocytes) on the other side, is sufficient justification to remove a diseased kidney, the one showing the tubercle bacilli and pyuria. I would like to ask Dr. Kretschmer how long he waits before he decides to operate upon a frankly diseased kidney.

Dr. Deming's description of his new operation was very interesting, because, as some of the other speakers have said, operations for ptosed kidney have not been regarded as successful; in fact, they have been considered a failure by many. I believe, however, that his new technic is a very good suggestion, and I shall be glad to try it in suitable cases.

Dr. Abraham Ravich: I would like to ask Dr. Deming whether in case of stone in a mobile kidney he would do a nephropexy as a routine measure after the pyelolithotomy, similar to what I believe Dr. Thomas of Philadelphia does; or would he consider the danger of infection from the pyelolithotomy too great to jeopardize this new nephropexy procedure.

Dr. Clyde L. Deming, Closing: Dr. Keyes has referred to pain due to lumbago as distinguished from that of renal origin. In the cases which I have presented in this paper lumbago was not to be considered, because none of them showed the particular spasm of the erector spinae muscles which is present in this condition. If the patient be examined on the table,

one will see that the side of the involved muscle will stand out prominently in comparison with the other side. Although such an examination was not done in all of these cases, I will admit, it was because there was no history pointing to it.

As to redundant ureters, I hardly know what to say, except to repeat what Dr. Caulk says, that it is no more important than extra length on the end of your nose. It is, as has been pointed out, common after operation; and if tortuous and not kinked, causes little disturbance in most cases. I noticed it and mentioned it in my paper, and I am asking you to look for it and study the condition. There is very little in the literature about it. In fact, I do not know that it is at all significant.

With respect to dilatation of constricted ureteropelvic junctions, my experience has been similar to that of Dr. Keyes. I do not get results. I showed one case where there was a stricture. I could show you many more, but it would mean nothing further than more pictures. In these cases I tried to pick out one of each kind as an illustration. I agree that it is difficult to expect results from dilatation of ureteropelvic junctions, for every time we injure it we get more stenosis and further away from the desired result.

Denervation of the kidney I have done only twice, in cases which did not have a ptosis but had a normal size, functioning kidney with a small and irritable pelvis. Both were relieved of pain. I do not know whether my stand in the matter has been right, but I have not considered denervation in relation to nephroptosis.

Dr. Barringer asked what the indications for nephropexy were. I do not know what all of them are. The cases operated on, however, have been patients totally incapacitated for work and in which it was necessary to get relief from pain. I believe the scope of the operation can be widened.

Dr. Rathbun has mentioned the history of nephropexy. I am fully cognizant of it. One should not run wild with this operation and do it on every kidney he sees, but I would use it only where patients are completely incapacitated and the pain is wholly within the kidney.

Dr. Osgood reports that he sees fewer and fewer of these cases. In the past four years I have seen increasingly more in New Haven.

I did not mean to imply to Dr. Stevens that 55 cases were relieved by dilatation. Only 15 were relieved. Fifteen patients are still hesitating about operative procedure, and I do not know what has happened to them since I saw them. About one-third were relieved by operation.

Dr. Beer referred to a more fixed operation for the kidney. There are several references in the literature to freeing the kidney and putting it in again, with claims that it stays fixed. These authors claim that there is no pain and no movement after such an operation. Whether this means denervation or a fixed operation is the question. I confess I do not know. Since my operation really does relieve ptosis and pain, why do a more fixed operation?

Dr. Ravich referred to ptotic kidneys with stones. I have only had 2 such cases in which I have done nephropexy. I do not do the operation in such cases as a routine. I do not consider all kidney stone cases as ptosed. I do it only where there is a marked kinking of the ureter, and where the kidney is very low.

I have presented the operation for what it is worth. If we do not get results, there is no harm done to the kidney. We do not strip the capsule, there is no damage to the kidney from sutures and it has the merit of being very simple.

Dr. H. L. Kretschmer, Closing: I have done but few nephropexies and make my indications for them perhaps unusually rigid. I have seen many patients who had been operated on elsewhere, who still complained of the same symptoms; and I feel exceedingly hesitant about doing an operation that may not give the patient relief. It may be that I am missing a lot and that there are some patients who should be operated upon whom I fail to operate.

With reference to Dr. Barringer's question about spinal anesthesia, I do not use it at the Presbyterian Hospital of Chicago. Personally, I am afraid of it. We feel that in the bladder cases sacral anesthesia or ethylene answers our purpose very well.

The question which kidney is to remain in renal tuberculosis is one that interests all of us, I am sure. At times it is exceedingly difficult to know just how one should interpret a case in which a few leukocytes (or perhaps no leucocytes) are found in the urine, and only a stray tubercle bacillus. As I mentioned in my paper, whenever there is any doubt in my mind, I always wait. I am never in a hurry to operate on these patients, and believe that one should take plenty of time to work out the diagnosis in each individual case to one's own complete satisfaction.

SPINAL ANESTHESIA: FATALITIES*

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VERY little is known about the various mechanisms by means of which death may be produced. Perhaps the best evidence regarding this assertion is the comparatively large number of cases in which the cause of death cannot be explained even after careful autopsy. Since under such conditions failure to explain mortality is possible even after careful autopsy examination, how much greater is the likelihood of erring in attributing a mortality to any particular cause if there be no post-mortem examination to check the clinical conclusion! There have been numerous fatalities following operation under spinal anesthesia. Some of these, in all likelihood, were due to the type of anesthetic employed; but a great many others, apparently, bore no relation at all to the anesthesia. Rygh and Bessesen[1] presented a list collected from the recent literature of 215,895 cases operated upon under spinal anesthesia in which there was a total of 75 deaths, a mortality rate of 1 to 3345. In 44,241 of these cases there were 29 deaths of which a fairly satisfactory record was given. Upon reviewing these 29 records, it was found that only 4 of the 29 were attributable to the anesthetic. The other 25 were either moribund before operation or they died 12, 14, 16 to 20 hours after operation, not as a result of the anesthetic, the effect of which long since had worn off, but because of the pathological lesion for which they were operated on. One of the 25, a strong healthy man about to be circumcised died following the spinal puncture without the injection of any anesthetic. The corrected mortality of 4 in 44,241 gave a mortality rate of 1 in 11,060. Even in these 4 deaths (which the authors attributed to spinal anesthesia) the possibility still remains that careful autopsy examination might have laid the cause to some other source.

In comparing the mortality rate of spinal anesthesia with that of any other type it must be remembered that statistics regarding the spinal anesthetic deaths will vary with the experience of those employing this form of anesthesia. It is true, also, that where spinal anesthesia is not used routinely it is selected as the anesthetic of choice because of some contraindication to another form of anesthesia. Furthermore such patients are as a rule of the type classed as poor operative risks. In some of these cases it is quite probable that no operation would have been undertaken under any other form of anesthesia. The hazard of operation was taken, despite the poor surgical risk, only because it was believed that spinal anesthesia offered an increased margin of safety. Likewise, statistics gathered at clinics wherein subarachnoid block is used routinely demonstrate a much lower death rate than those emanating from hospitals where spinal anesthesia is used only occasionally. It must also be remembered that a correct comparison between the mortalities resulting from spinal and other forms of anesthesia, particularly inhalation narcosis, must take into consideration what might perhaps be called remote, late or delayed deaths from the latter type of anesthesia. In the case of spinal anesthesia the mortality is usually dramatic, resulting shortly after the introduction of the anesthetic into the subarachnoid space; whereas, with inhalation anesthesia the mortality may not occur until a considerable time after the completion of the operation. McGrath[2] of the Mayo clinic reported 49,057 ether administrations with no deaths attributable to the anesthetic alone. This was considered to mean no deaths in 49,057 cases. Still, from the same clinic, although not covering the identical period of time, Lundy[3] reported 21 deaths in 600 cases in

* Crown Heights Hospital, Brooklyn, N. Y. Submitted for publication May 2, 1930.

6 of which he believed ether to be at least partially responsible. These contradictory figures are mentioned to show how statistics may mislead. The value of any statistical study depends less upon the tabulated figures than upon the thoroughness with which all the modifying factors are set forth and discussed. Even when compiled with the utmost care, statistical findings should be subjected to sharp scrutiny and unbiased criticism. Undoubtedly, in a comparatively large number of cases in which operation is done under inhalation narcosis and which result fatally and death is recorded as due to sepsis, infection, pneumonia, shock, uremia, vascular collapse, myocarditis, the fatalities are due to ether anesthesia. Such deaths are not charged against the anesthetic because the patient survives the operative procedure and does not die until some time after the operation has been completed. A death from an anesthetic like ether need not necessarily occur during the time of the administration of the anesthetic. William B. MacNider in 1925[4] demonstrated that ether was quite toxic particularly in older organisms and that the toxicity is shown by an alteration in the alkaline reserve of the blood and that as soon as such alteration occurs there is a reduction in urine formation or the establishment of an anuria. The indictment against ether as a factor in the production of postoperative pneumonic processes is an old one and needs no discussion here.

One cannot help but be impressed with the manner in which spinal anesthesia facilitates abdominal surgical procedures. In patients having obstruction, for instance, operated upon under inhalation anesthesia, the operator causes unnecessary and harmful trauma to the intestines and the peritoneal covering because of a failure to secure as good relaxation as that which is possible under spinal anesthesia. Hence, the increased mortality rate must be laid, at least, in part, to the inadequacy of the anesthetic. If the application of a particular type of anesthetic to a large group of surgical cases can reduce the surgical mortality by facilitating operative procedures, the beneficial results it seems fair to state would by far outweigh any slight increase in the direct anesthetic mortality that one might presume to exist if one accepts the published statistics without a too critical review of the circumstances. There are, probably, many more spinal deaths than those which have been reported in the literature. Surgeons are more prone to publish their successes than their failures.

Mention has already been made, elsewhere, of the apparent inconsistency regarding the relation of respiratory paralysis to spinal anesthesia.[5] We know, now, that the danger of respiratory failure as a result of the action of the drug upon the medulla consequent to upward diffusion is negligible. One becomes particularly impressed with this upon reading the records of many cases wherein as high as 1200 mg. of novocaine have been injected into the subarachnoid space without any untoward results.[6] With the average dose varying from 100 to 150 mg. injected into the subarachnoid space between the second and third lumbar vertebrae it is difficult to understand how the anesthetic solution could diffuse upward to the medulla in sufficient concentration to produce respiratory paralysis when, under similar circumstances, the use of ten times that amount of anesthetic (in which case the relative amount of upward diffusion would be ten times as great, and therefore much more dangerous) is safe. Another explanation must be sought for deaths under spinal anesthesia. Greater care in observing the phenomena attending fatalities and thorough autopsies will be of inestimable value in dissipating the mysteries which surround these tragic cases.

Few characteristic autopsy findings have been reported after spinal anesthesia deaths.

V. Brunn[7] in an excellent monograph first cited the animal experiments of Van Lier[8] who demonstrated swelling of the

nucleus of the ganglion cells, and wandering towards the periphery after spinal anesthesia. It was shown that these changes were reversible with the cessation of anesthesia. Wassidlo[9] concurred in these findings. Spielmeyer[10] in a patient who died under spinal anesthesia, found definite involvement of the ganglion cells. There was marked chromolysis, dissolution of the nissl bodies and rounding of the cell bodies. There was also dissolution of the nuclear membrane. Spielmeyer concluded, however, that these changes were not directly attributable to the toxic effect of the drug employed (stovaine) but were the sequelae of the circulatory disturbance following the cessation of respiration.

In three patients Spielmeyer observed similar lesions, mainly in the large anterior cells of the spinal cord. In his opinion these lesions correspond to the ones seen in secondary retrograde ganglion destruction. Finding similar lesions after injection of stovaine into animals, he reasoned that the action was primarily a direct toxic effect upon the axon cylinders with the consequent secondary retrograde degeneration of the ganglion cells. In a dog and three monkeys in whom he induced a flaccid paralysis Spielmeyer found widespread lesions of the large anterior horn cells, especially marked in the periphery of the spinal cortical portion. The most intense reaction was present in the nerve fibers of the anterior columns of the lumbar and sacral regions. Evidence of degeneration was seen throughout the entire length of the posterior columns as well as in the posterior roots.

Perhaps one might be able to explain upon this basis the delayed action in abducens paralysis which is encountered at times and leads to a temporary external ocular palsy! The axon cylinder is exposed to the direct toxic action of the injected anesthetic substance. Following the preliminary degeneration possibly thus induced, a secondary degeneration of the ganglion cell results. With marked circulatory stasis, however, this course does not take place since the more sensitive ganglion cells are earlier destroyed.

Similar observations made by Klose and Vogt[11] in animals led them to conclude that the action is direct and toxic and not due to circulatory depression.

It seems worth while to consider this topic at greater length and to submit reports of some of the published mortalities so that a proper evaluation may be made. The following are quoted by Rygh and Bessesen.[1]

1. A man, aged sixty, with gangrene of the leg and thigh from a crushing injury, moribund, died fifteen minutes after injection.

2. A man, aged twenty-nine, with avulsion of the arm at the shoulder, shocked and pulseless, was given a high injection and trimming of the injury was attempted. Respiratory failure resulted but he was kept alive six hours with artificial respiration.

3. A debilitated man, aged sixty-five, moribund from typhoid perforation with peritonitis of twenty-four hours' standing, injected when nearly pulseless, died during the operation.

4. An infant, twenty-one months old, with miliary tuberculosis, peritonitis and abscess of the lung, stopped breathing when an attempt was made to find the lung abscess by operation.

5. An obese man, aged fifty-five, with extensive intestinal gangrene and advanced diffuse peritonitis died during operation.

6. A woman, aged forty-five, with diabetes and chronic nephritis, sustained fractures of both femurs, pelvis and several ribs, and died of collapse and shock.

7. A man, aged thirty-five, suffered from advanced tuberculosis with acute urinary retention.

8. A woman, aged eighty-four, had a strangulated femoral hernia of six days' duration and fecal vomiting for two days.

9. A man, aged seventy-two, suffered from strangulated hernia, with fecal vomiting, seventy-two hours prior to operation.

These patients were moribund and in many instances no operation would have been undertaken had it not been for the employment of spinal anesthesia which was considered to give a greater margin of safety. The fatalities were apparently

inevitable, regardless of the type of anesthetic.

10. A man, aged seventy-two, with strangulated hernia, rapid irregular pulse, died two hours after operation.

11. A man, aged sixty-three, non-transportable, with ruptured appendix died on the table.

12. A woman, with ruptured uterus and dead fetus, died a half hour after injection without an operation being undertaken.

13. Patient died of shock.

14. Patient died of shock.

From the reports of these 5 cases it is apparent also that these patients were suffering from shock which in all likelihood contraindicated any operative procedure.

15. A man, aged forty-three, had an enormous empyema with an extensive subcutaneous phlegmon of the chest wall. Cessation of the heart action followed rapid evacuation of pus.

16. A man, middle-aged, had a sudden cessation of the heart when evacuation of a large amount of pus from the thoracic cavity was attempted.

17. A woman, aged fifty-two, had a rib resected and three pints of pus evacuated.

It is difficult to explain the results in these cases. The authors quoted believe that the nerves of respiration and vascular control which are largely centered in the thoracic and cervical regions offer contraindications to operations above the diaphragm. Death is blamed upon the rapid evacuation of the pus in Cases 15 and 16. In our experience with empyema thoracis there is no contraindication to the rapid emptying of the chest cavities. Indeed, our method consists of the introduction of a trochar into the abscess cavity and the aspiration of the pus under strong suction.

18. A woman aged sixty, had a gall bladder operation with peritonitis.

19. An obese man of fifty died following a gall bladder operation with peritonitis.

One of the chief factors in the postoperative treatment of acute peritonitis is Fowler's position. To employ spinal anesthesia with safety, it is necessary that the head of the patient be lowered during the operation and for three hours following the injection. These positions are incompatible. On this account, in a severe peritoneal infection, where Fowler's position is a constant desideratum, spinal anesthesia would be inadvisable.

According to the authors' comments it would seem that these patients died subsequent to the completion of the operation after having been placed in Fowler's position because they were not in Trendelenburg posture. Unfortunately, this point is not quite clear. It seems unnecessary to state that no matter how severe the infection, if operation has been performed under spinal anesthesia the Trendelenburg position should be maintained until the anesthesia has worn off.

20. A patient received 9.5 grains of procaine, remained living while in Trendelenburg position, but died when brought to level.

21. A patient received 9.5 grains of procaine remained living while in Trendelenburg position, but died when brought to a level.

The authors in their comments claim that the results were toxic deaths due to overdosage but it seems quite clear that the explanation for the fatalities was in the change of the patients' position from that of the Trendelenburg to the horizontal.

22. An old man died from injection of butyn.

23. Toxic death due to stovain.

24. Toxic death due to stovain.

Butyn is more toxic than cocaine; and both are too toxic for spinal or sacral anesthesia. Deaver condemns stovain for spinal anesthesia. [Authors' comment.]

25. An eclamptic pregnant woman to be operated by cesarian section received the spinal injection and died during a convulsion with cyanosis, apparently from asphyxia.

Clinically this is an eclamptic death. [Authors' comment.]

26. A strong, healthy man about to be circumcised, died following spinal puncture without the injection of any anesthetic.

27. A man, aged forty-three, with an extensive bilateral fibroid tuberculosis and subacute tuberculous laryngitis suffered from a severe dysphagia especially for fluids. The spine was

drained of 7.5 c.c. of fluid in a sitting posture and then 1.25 grains of apothesin dissolved in distilled water injected. The patient was placed with his head on a pillow and developed immediate fatal respiratory paralysis.

This is an excellent example of what may be expected after spinal anesthesia if the Trendelenburg posture is not employed.

28. A young woman being operated upon for retroversion of the uterus, developed collapse, was revived twice with adrenalin solution, but finally died when this stimulus was attempted for third time, four and half hours after operation.

29. A woman, operated on for cyst of the ovary, died when the cyst was punctured, apparently of collapse.

These cases are copied to exemplify our statement that the material available for judgment of the mechanism by which death occurs is inadequate, too meager really, to allow of any accuracy. In the discussion of the value of spinal anesthesia before the Society of Surgery in Paris in 1923 and 1924, 20,267 cases were recorded and published in which there were 10 deaths.

These cases were quoted and discussed by Sylva and are tabulated below.[12]

	Spinal Anesthesias	Deaths
Duverguey	2256	1
Jonessco	5481	0
Dujarier	4000	4
Cauchois	500	1
Plission and Clavelin	1011	0
Lepoutre	500	0
Leclerc	300	0
Labey	680	3
Sauve	1000	0
Chifolian	1000	0
Riche	3539	1

Duverguey's Case: This treats of a patient with an old abscess of the lung. He made an injection of scopolamine, then removed 10 to 15 c.c. of cerebrospinal fluid, committed barbotage and injected all cocaine-adrenalin. The patient died in coma with temperature of 40°, eighteen hours after the operation. Details for duly estimating it are lacking, but the fact of being treated for an abscess of the lung, that he died with a temperature of 40 makes one suspect that there could have been an infection.

The lapse of eighteen hours after the operation is certainly sufficient to eliminate this case as a death to be charged against spinal anesthesia.

Dujarier's Cases: He had 4 deaths. He gives no details, states that they died of asphyxia, and adds: "I had 4 cases of death due to operations, but always in cancer, cachexia or occlusion. I never had cases of death in young people without tumors. It would seem that these cases cannot be charged to spinal anesthesia."

Case of Cauchois: A woman, fifty years old, operated on urgently for a complicated fracture of her leg; dead at the beginning of her operation. He does not give details and attributes the death to the fact that he always uses the solution prepared by Carrion, and this time he used a solution prepared in the pharmacy of the hospital.

Labey's Cases: A woman treated for a long time for a very serious angiocholitis. He says: "I do not think this death can be charged to spinal anesthesia; that it probably would have occurred, I believe, with another anesthesia."

Second: Cancer of the stomach, cachectic, died in a faint. He declared that "the sick woman would not have tolerated general anesthesia."

Third: Hysterectomy on account of an old hematocele and cyst of the ovaries. Unconsciousness at the time of suturing. He noted that the solution had a yellow color; it was, consequently defective.

Riche's Case: Dead on account of meningitis.

An analysis of these reported deaths shows that the first case of Duverguey is unquestionably not due to spinal anesthesia. The next 4 cases of Dujarier whose deaths are taken from a series of 4000 were apparently extremely bad risks. The mere fact that he himself excuses the anesthesia from responsibility should not be taken too seriously but his statement that he never had cases of death in young people without tumors is of importance because it helps to give a clearer picture of the condition of the patient who died. The details in the case cited by Cauchois are too meager to deserve any other comment beyond the one that there is no evidence that the solution was not a good one. In Labey's

cases apparently the first two were very seriously ill and there is as much likelihood that they died of the pathological lesion for which they were operated on as for any other reason. The third case of his may, perhaps, be charged against a defective solution.

Silva reviews also the following mortalities.

Two cases of André were published by Schevassi. One, a man of sixty years, suffering from disorder of the prostate, albumin in the urine, with serious retention, dead in a swoon. He does not describe the technic. The other, a man seventy-six years old, suffering from prostatic disease, albuminuric, with complete retention. Dead three hours after the prostatectomy. He does not give the technic. Lepoutre added the fatality in a man, quite fat, with two large herniae, with glucose and acetone in the urine. Lepoutre withdrew 10 c.c. of cerebrospinal fluid, injected 0.1 gm. of syncaine and committed "barbotage." The patient died eight days later with jaundice.

We do not see the responsibility of spinal anesthesia.

Sauve reported 3 cases:

An advanced cancer of the uterus. A woman with intestinal occlusion, and a hysterectomy with salpingitis, dead ten hours later.

He did not give details, but from the explanation one sees that they were cases where the responsibility of spinal anesthesia was quite problematical and extremely doubtful.

Auvray published the following case:

A woman, seventy years old, always in poor health, bronchitis during the winter, a large cyst of the ovary. Difficult breathing appeared, then a sense of suffocation, interrupted speech and a pulse rate of 120. The necessity to administer digitalis arose. A sick woman, notably lean with an accentuated ovarian cachexia. [Auvray considered general anesthesia highly dangerous, and employed spinal anesthesia, withdrawing fluid and injecting 0.12 gm. of novocaine.] The patient was dead five minutes after the injection.

Faure called attention to a man operated on after three strangulated herniae, who died on the following day with black vomiting. Faure stated that he did not attribute the death to spinal anesthesia.

Barthelemy reported the case of a woman, sixty years old, with a strangulated umbilical hernia and chronic tracheitis that contraindicated general anesthesia by ether or chloroform. He induced spinal anesthesia with 0.12 gm. of novocaine after withdrawing 25 c.c. of fluid. Died.

The same man presented the case of a boy, nineteen years old, with an inguinal hernia; withdrawal of 25 c.c. of cerebrospinal fluid, injection of 0.12 gm. of novocaine and dead in two months from meningitis.

It is seen from these additional cases that the reports furnish insufficient data for drawing any valuable conclusions.

Brun[13] reported 6147 spinal anesthesias in the hospital Sadiki from 1919 to 1928 with 3 deaths. One was in a man of seventy years, who was cachectic and who was operated upon for an extravasation of urine. The second was for a strangulated hernia in an old woman, the strangulation having existed six days. The third was an amputation of the thigh in a sixteen-day old child because of a spreading gangrene following the application of a plaster cast for a fractured femur.

His own commentary is to the effect that the gravity of these cases did not permit the death to be charged to the spinal anesthetic.

Four cases in which mortalities resulted were published by us in the American Journal of Surgery in 1928. These cases and several others which we shall add we feel should be incorporated in this work.

One patient who expired on the table was a man of sixty-seven operated upon forty-eight hours after the onset of acute intestinal obstruction which operation disclosed to be due to an annular carcinoma of the cecum. He was so dehydrated and so highly toxic that only with reluctance and because of the minimizing effect of spinal anesthesia on operative trauma was the operation undertaken. Another death occurred in a highly toxic diabetic patient of sixty-two with a rapidly spreading gangrene of the foot and leg. During the course of a guillotine operation at the middle third of

the thigh, his pulse suddenly became imperceptible and stimulation failed to restore the circulation. Another fatality occurred in a child of six. She had been treated with ice-bags at home for a supposed appendicitis and the abdomen was sectioned three days after the onset of the illness on a provisional diagnosis of obstruction. At this time, she was thoroughly dehydrated, highly toxic and but a degree removed from death. At operation, a Meckel's diverticulum was found to have caused complete obstruction and gangrene of about 4 ft. of small intestine. During the resection, her life ebbed out. The fourth death occurred in a woman aged fifty-two who had been bedridden for three years because of a severe myocarditis with several attacks of decompensation and who came to operation for a suppurative appendicitis with localized suppurative peritonitis of three days' duration. Appendectomy was done, drainage was instituted and the wound closed. After the dressings were applied, and as the patient was about to be transferred to the stretcher for transportation from the operating room, she ceased to breathe suddenly and the heart beat became imperceptible. The wound was opened quickly and transdiaphragmatic massage of the heart instituted. Intracardiac stimulation and artificial respiration failed, however, to prevent death.

Since that time, we have had several other cases which we feel should be added to this list and of which we shall write in as much detail as possible.

The first was one of carcinoma of the breast which was operated upon under spinal anesthesia (200 mg. of neocaine dissolved in 8 c.c. of cerebrospinal fluid) the operation lasting forty-five minutes. While the skin was being closed, for no demonstrable reason, the patient ceased breathing. A rather exhaustive autopsy failed to reveal any reason for the fatality. No brain examination was made because permission could not be secured. This patient was forty-nine years of age and apparently in good health otherwise. Preoperative study resulted in her classification as a good operative risk. Another patient, thirty-seven years of age, with a well marked bronchial asthma was operated upon under spinal anesthesia for prolapse of the uterus. She was given 150 mg. of neocaine dissolved in 4 c.c. of cerebrospinal fluid, injected between the second and third lumbar vertebrae, and ceased to breathe within ten minutes without any warning, whatsoever. Efforts at resuscitation failed. No autopsy was obtainable in this case and this is one of the types in which the mortality might be directly attributable to spinal anesthesia.

Under these circumstances, however, the question can rightfully be asked "what was the mechanism of death?" Since the amount of the anesthetic injected was no greater than that employed in thousands of other cases, the injection having been made at the same site, the same amount of solvent having been used, how, then, can the mortality be attributed to spinal anesthesia in view of the large number of cases in which much greater quantities (as high as 1200 mg.) were injected into the subarachnoid space without fatalities?

Another case of an extensive alveolar carcinoma involving the entire left breast in a woman of fifty-seven who claimed she had the lesion for thirteen years and in whom there was a large axillary metastatic focus but without any other demonstrable lesion was operated with the endotherm under spinal anesthesia. This patient received 300 mg. of neocaine dissolved in 10 c.c. of cerebrospinal fluid. Ten minutes after the operation was begun, respirations ceased. Artificial respiration was maintained and an intracardiac injection of adrenalin was given about one minute and one-half after respiration had apparently ceased, and the pulse and heart beat had become feeble. Within two and one-half minutes respirations began spontaneously. Three days postoperatively, she developed a severe infection of the wound with high temperature, gangrene and sloughing and expired on the fifth day after operation.

This is quite evidently a case in which the mortality was not due to spinal anesthesia but rather to the severity of the type of infection.

Another patient, a female, aged forty-eight, had multiple large fibroids of the uterus for which she was operated upon under spinal anesthesia, 150 mg. of neocaine dissolved in 4 c.c. of cerebrospinal fluid being injected between the second and third lumbar vertebrae. The median lower abdominal incision

was made and the fibroids inspected. In the right lower quadrant a retroperitoneal mass was distinguished as coming from the lower pole of the right kidney which was prolapsed. The peritoneum to the outer side of the cecum was opened, a solitary cyst of the lower pole of the right kidney was excised, and the peritoneum closed. A hysterectomy and appendectomy were then done. Before the abdomen was closed, the gall bladder was palpated and was found to contain a large number of calculi. The lower incision was closed and an upper abdominal incision made. About fifty-three minutes had elapsed from the time of administration of the anesthetic and, while the upper abdomen was being incised, the patient complained of considerable pain. It was realized that the cholecystectomy could not be performed unless some additional anesthesia were given. Instead of our rolling the patient over and giving another spinal anesthetic as would have been done had the skin incision not already been made, gas-oxygen and ether were administered. When the patient was anesthetized, the gall bladder was quickly removed. As the closure of the peritoneum was begun it was noticed that respiration had ceased. Artificial respiration was instituted and intracardiac adrenalin stimulation given. After a lapse of five minutes the patient resumed breathing and shortly afterward was returned to her bed. She did not, however, regain consciousness and expired thirty-six hours after the operation.

It would seem that this fatality might have been due to a period of cerebral anemia lasting approximately five minutes as a result of which there was sufficient degeneration or injury to the brain tissue from which recovery was impossible. *The cessation of respiration which occurred in this case came after the spinal anesthesia had worn off.* It is impossible for the authors to see how this fatality could in any way be blamed upon spinal anesthesia. This case, however, is emphasized because of the similarity to the one which preceded it, namely the carcinoma of the breast case. Had the situation been reversed and cessation of respiration in the gall bladder case occurred early in the operation, the temptation to indict the spinal anesthetic would have been strong. Under the existing circumstances, however, if the anesthetic were at fault, it was gas-oxygen-ether and not spinal anesthesia. It is easy to see how the etiological factors in both these 2 last cases could be mistaken one for the other. Even with the finest detailed description, unless chemical evidence of the activity of the drug upon the vital centers be obtainable, the scientific proof of the mechanism by which death is occasioned cannot be determined beyond a doubt.

Another case is that of a tonsillectomy in a boy of nine years of age operated upon under spinal anesthesia. He was given 150 mg. of neocaine dissolved in 6 c.c. of cerebrospinal fluid. The injection was made between he second and third lumbar vertebrae. Satisfactory anesthesia of the entire body resulted. The operation was completed rapidly and the patient returned to bed. About ten minutes after he was placed in bed, oozing from one of the tonsillar beds became brisk. In order to facilitate the expectoration of blood, a new nurse (unacquainted with the details of technic necessary for the maintainance of safety in patients who have been operated upon under spinal anesthesia) sat him upright in bed. He remained in the sitting position for about two one-half minutes and then ceased to breathe. Efforts at resuscitation failed to revive him. This, unquestionably, was an anesthetic death due to spinal anesthesia. It is believed that this death, however, could have been avoided had the patient been kept in the Trendelenburg posture or at least in a horizontal position.

In another case a male fifty years of age, obese and emphysematous, operated under spinal anesthesia for a perforated appendix with peritonitis developed paralytic ileus. On the fourth day postoperatively, because of continued vomiting not controlled by lavage and paralytic ileus which did not respond to eserin, pituitin, enemata and hypertonic sodium chloride intravenously, it was decided to try to stimulate intestinal peristalsis by spinal anesthesia. One hundred and fifty mg. of neocaine dissolved in 4 c.c. of cerebrospinal fluid were injected at the usual level. The patient was immediately placed in Trendelenberg position. One minute later, he became cyanotic, began vomiting so copiously that he aspirated a large quantity of the vomitus and expired. At autopsy the lungs were found to be water-logged with the brackish vomitus.

A young woman in the early thirties, eight months pregnant, in whom an operative delivery was decided upon because of hemorrhage from a central placenta previa was given 150 mg. of neocaine in the usual manner. After she was placed in the Trendelenberg position, the operator manually dilated the vagina and cervix and then plunged his hand through the placenta to do a version. A foot was grasped and as the rotation was begun it was noticed that the patient became cyanotic, ceased to breathe, had dilated pupils and shortly thereafter lost vascular pulsations. A living child was delivered but the mother died. An autopsy was not obtainable.

Two of these deaths (the tonsillectomy and obstetric cases) do not belong in our operative series but were included because the anesthetics were administered by us and we were present to record the phenomena attending the fatal outcome. The others, 9 in number, were the total number of deaths which might have been attributed to spinal anesthesia out of a total of almost 6000 cases.

Aside from these cases, we have had no fatalities which *even remotely* might have been considered as due to the anesthesia. It is our feeling in analysing these cases that the tonsillectomy death was an anesthetic death directly due to the failure to observe the necessary precautions. Regarding the others, despite the fact that in some cases autopsies were performed and as many details gathered as possible, there was no definite scientific evidence indicting spinal anesthesia. These mortalities could easily have been duplicated under any other form of anesthesia and perhaps much more easily in several of the cases cited. On the other side of the balance may be placed a large number of cases of patients operated on under spinal anesthesia that resulted favorably. These are cases which in the judgment of the operator certainly could not have terminated favorably had they been operated upon under any other form of anesthesia. This is especially true of cases of intestinal obstruction with considerable toxemia. The reduction in the surgical mortality rate by the use of an anesthetic which diminishes trauma and diminishes shock, increases peristaltic movement and thus gives an additional margin of safety for the patient, undoubtedly saves many lives. This additional safety factor in so large a number of cases far outweighs the possible slight increase in death by direct anesthetic mortality.

Of our total number of almost 6000 general surgical cases there were only 6 deaths on the operating table. All these received spinal anesthesia, and are included in the 9 listed as possible anesthetic deaths. How many "table" mortalities a year does the average active surgical service have under inhalation anesthesia? In this same series of almost 6000 cases, how many deaths would have occurred on the operating table under any other form of anesthesia? How much greater would the total mortality have been under any other form of anesthesia? The answers to all these questions cannot at present be determined with scientific exactitude because no parallel control series is possible. The nearest approach to an answer of value is the clinical impression of the individual operator with an extensive experience.

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ROENTGEN EVIDENCE OF

ADHESIONS OF THE SMALL INTESTINE*

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IN this paper we wish to direct attention to the possibility of *x*-ray diagnosis and operative correction of adhesions involving the small intestine. The growing interest in roentgen diagnosis of small intestinal states is attested by the papers of Kornblum[1] and Ritvo.[2] The technic is described in Soper's[3] recent article.

FIG. 1. A typical pattern of small intestine following appendectomy, of type that produces no symptoms. Five and one-half hour observation.

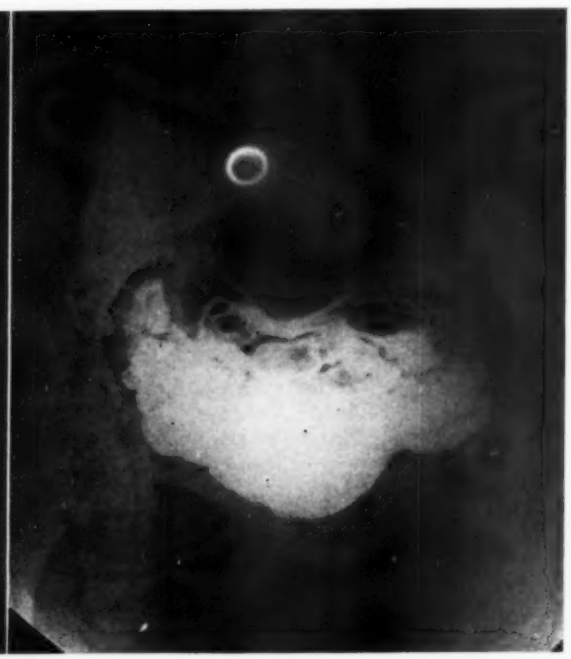

FIG. 2. Another case producing atypical pattern that followed appendectomy. Not to be regarded as pathological.

Adhesions may be divided into 3 classes. The vast majority are postoperative in character but some are produced by former inflammatory processes. We have designated the usual adhesions that follow appendectomy as Grade 1. In this type the coils of the terminal ileum are matted together; i.e., adherent to each other. No symptoms are produced by this form.

In adhesions of Grade 2 one or more bands are formed which attach a coil of the gut to some neighboring organ or to the abdominal wall. This type may produce no symptoms. However, it forms a trap that may catch a loop of the bowel and produce acute obstruction. Often a patient gives a history of several attacks of partial obstruction, with complete absence of symptoms between the attacks. The most careful *x*-ray examination may fail to disclose these bands, but the alert observer will usually find atypical dilated coils.

Adhesions of Grade 3 form definite bands which bind down the intestine and form a partial stenosis of the lumen and interfere with function, as illustrated by the adhesive bands that constrict the terminal ileum. This type is more easily demonstrated by roentgen examination. The symptoms are usually dull pain located

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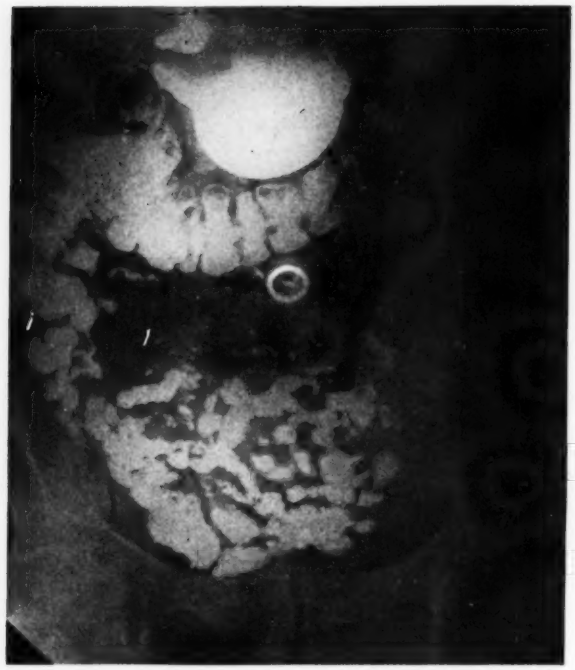

FIG. 3. Atypical pattern of small intestine following appendectomy not regarded as pathological. Patient, however, developed definite attacks of partial obstruction and operation disclosed definite adhesive bands binding down terminal ileum. This case is of extreme importance inasmuch as it illustrates that we are justified in operating on basis of history alone when no real *x*-ray evidence is presented.

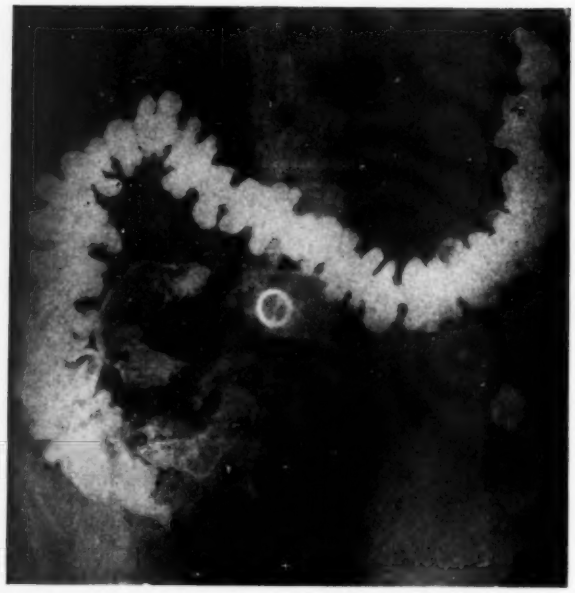

FIG. 4. Twenty-four hour ileal stasis. Young woman who had several attacks of partial obstruction following operation for gallstones one year ago. Operation strongly advised but declined until acute complete obstruction had occurred necessitating immediate surgery. Strong fibrous bands located in ileum. Exitus.

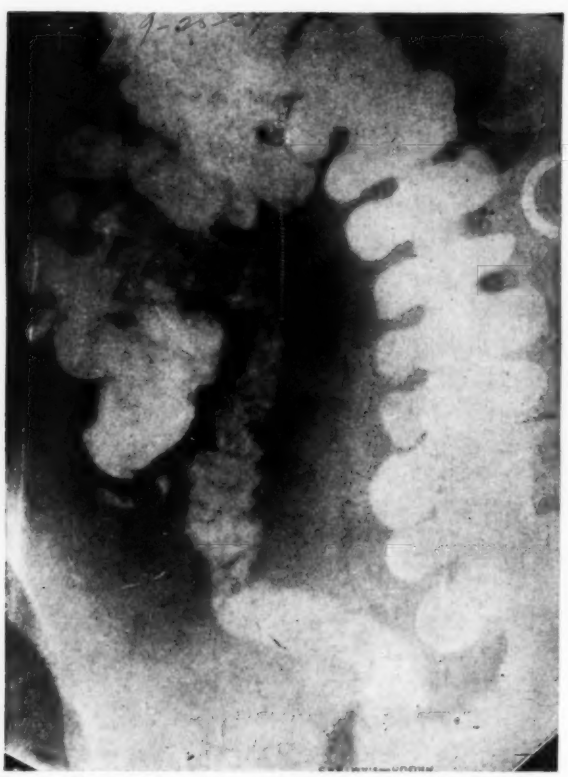

FIG. 5. Twenty-four hour stasis of terminal ileum following attacks of appendicitis. Operation disclosed strong band binding down appendix and ileum at ileocecal valve.

FIG. 6. Partial obstruction of lower ileum due to Meckel's diverticulum. Operation disclosed several loops of ileum attached to diverticulum. Male, aged nineteen years, a chronic invalid for past two years. He was much emaciated. Note dilatation and sacculation of ileum on six-hour films, also gastric motor delay. Now three years after operation and he has remained in perfect health.

FIG. 7. Patient female, aged fifty-two, had exploratory abdominal section in 1925 with negative results. Came under our observation in 1927. Atypical loops observed on six-hour film. Patient had suffered from attacks of partial intestinal obstruction since operation. Second operation revealed a band about 3 ft. from ileocecal junction. Good operative recovery. (Lower arrow marks narrowing corresponding to exact location of band.)

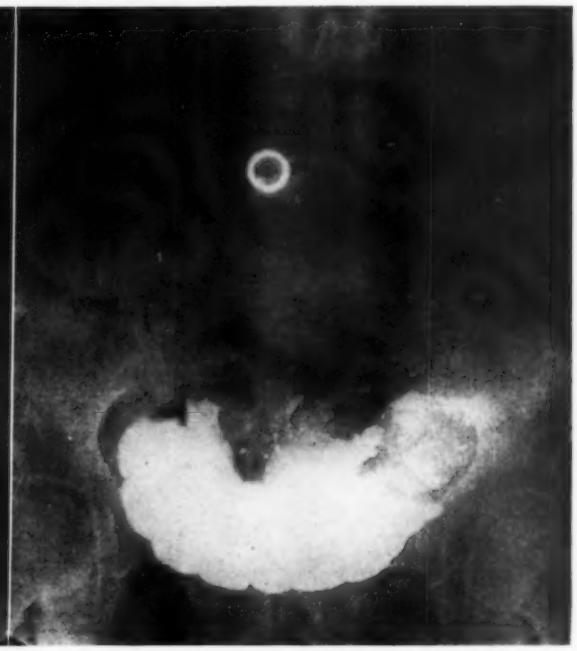

FIG. 8. Same patient as in Figure 7. Normal intestinal loops three months after operation.

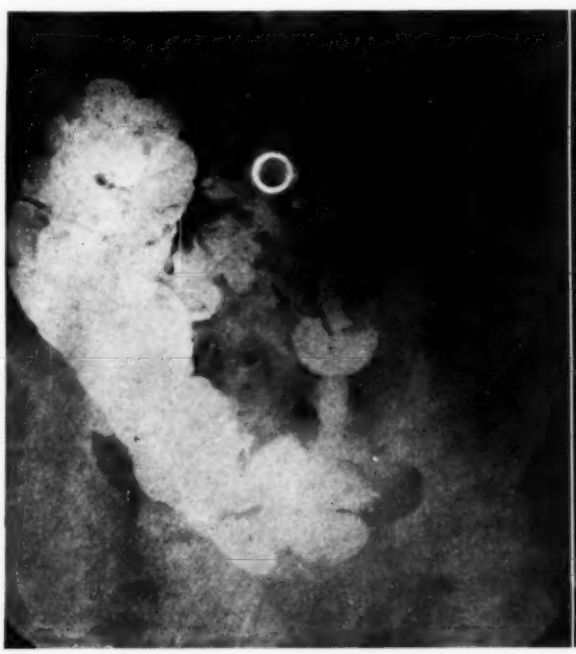

FIG. 9. Adhesive bands involving lower ileum. Atypical loops were best seen at five and a half hour observation. There was no twenty-four hour ileal stasis. Operation disclosed a pathological appendix adhering to terminal ileum in such a way as to cause a kinking which resulted in partial obstruction of bowel. This patient, a female, aged forty years, gave a history of attacks of appendicitis as well as attacks of partial obstruction.

FIG. 10. Same patient as in Figure 9. Film secured six weeks after operation. Normal intestinal loops. Patient made perfect recovery and has had no symptoms for past two years.

FIG. 11. Two years ago this patient, a robust young man was operated upon for appendicitis. He complained of pain located at upper part of abdominal scar corresponding to dilated loop depicted on film. No history of obstruction. Second operation disclosed an adhesive band binding down a loop of ileum. Perfect recovery.

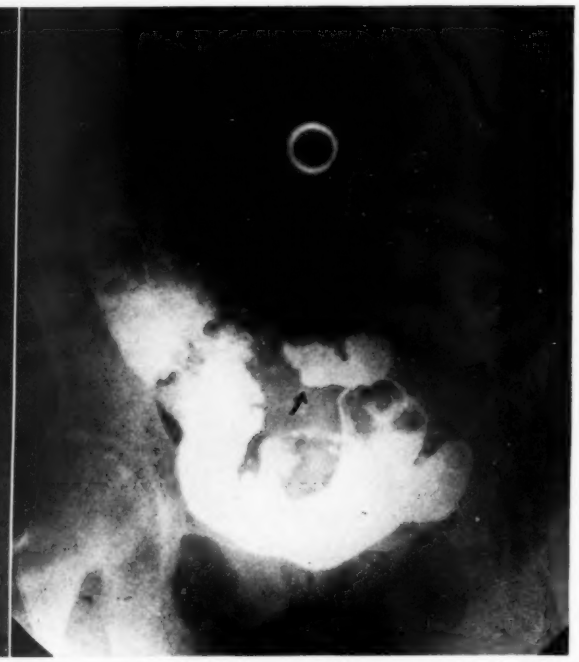

FIG. 12. Atypical loops which apparently indicated adhesions involving terminal ileum. At operation no adhesions found involving small intestine but a strong band caused partial stenosis of ascending colon at junction with cecum. Case of Mill's recoil phenomenon.

FIG. 13. One year after appendectomy. Patient had succession of attacks of partial obstruction. At operation firm fibrous bands bound down terminal ileum. Good recovery.

FIG. 14. Patient, female, aged thirty, operated upon three years ago for pelvic condition. Again one year later for adhesions. She had several attacks of partial obstruction and because of her complaints and good general condition she was rated as postoperative neurotic. This film secured at six and one-half hour period. Third operation disclosed four definite adhesive bands of Grade 3. One year after operation and she is free from symptoms.

FIG. 15. These atypical patterns secured in patient suffering from attack of acute cholecystitis. At operation no adhesions were found. Atypical loops probably resulted from general disturbance in gastrointestinal motility induced by severe pain. One must not judge small intestinal patterns during abdominal pain or migraine attack.

FIG. 16. Patient had uterine suspension operation ten years ago. Acute intestinal obstruction occurred Nov. 9, 1929. Operation disclosed strong band binding down the terminal ileum. Loop tremendously distended and congested; no resection done. Dec. 27, 1929 when patient was having mild attacks of acute obstruction. Final good function followed mild laxatives and smooth diet.

FIG. 17. Same patient as Figure 16. Review of her history disclosed symptoms of dysfunction of small intestine. This film was made three years ago and reveals atypical loops which were not recognized at that time.

FIG. 18. Appendix operation two years ago. Colicky pains, nausea and vomiting attacks since. Roentgen examination showed atypical duodenal pattern as barium was leaving stomach. At operation duodenal loop found to be adherent to abdominal wall. Good recovery.

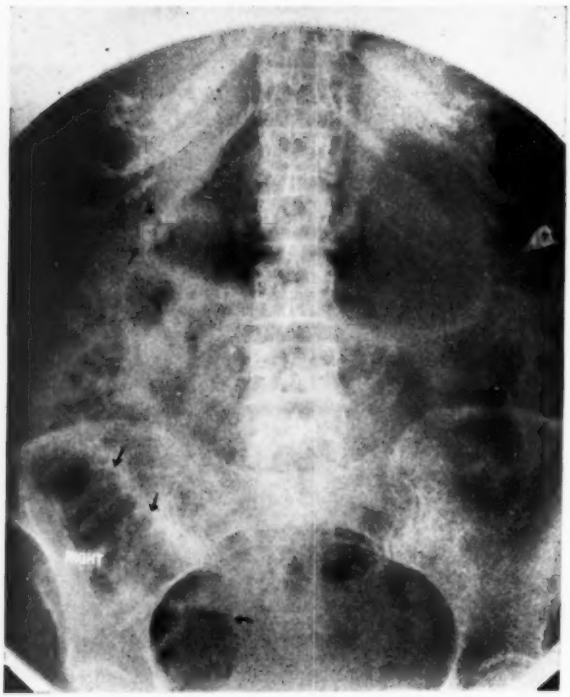

FIG. 19. This film was secured prior to the operation in patient aged sixty-five. Had suffered from duodenal-ulcer and gallstones but refused surgery. Stones can be seen in upper right quadrant. The gallstone attacks always atypical in character. She suddenly developed symptoms of very acute obstruction and was operated upon. Lower dilated loop designated by arrow found to be jejunum. Bowel was almost gangrenous but circulation returned and resection was not done. Good recovery. Her original operation was for uterine suspension twenty years ago.

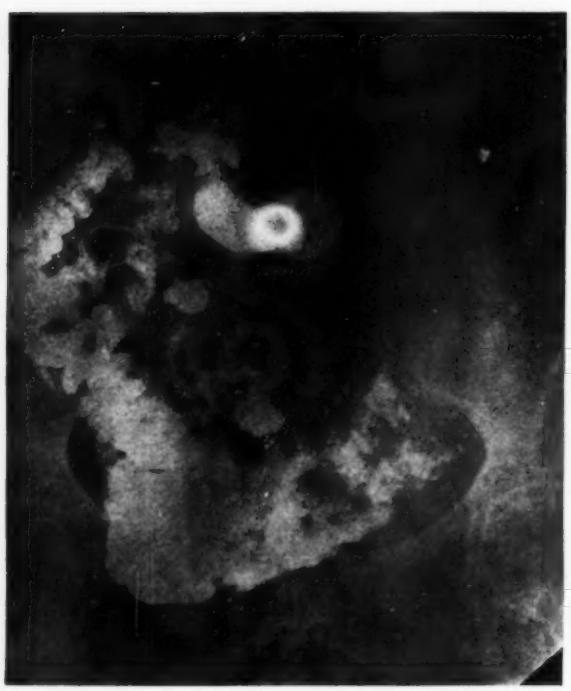

FIG. 20. In reviewing her history we can read partial obstruction. This six-hour film taken in 1924 with gastric motor insufficiency, duodenal cap deformity and atypical loops explains many of her attacks which were erroneously attributed to gallstones.

FIG. 21. This film shows a tremendous distension of entire small intestine taken just before operation. General peritonitis present. No obstruction. It is obviously characteristic of ileus.

FIG. 22. Patient female, aged fifty-one. Entered St. Luke's Hospital with symptoms of acute intestinal obstruction April 2, 1929. Eighteen months ago her kidney was removed and peritonitis developed. This film was secured and operation advised but declined. She eventually recovered from attack, but atypical pattern remains and doubtless other attacks will occur.

FIG. 23. This is position of small intestine assumed in postoperative hernia following operation for pus appendix one year ago. No obstructive symptoms. No operation advised.

FIG. 24. Atypical loops occurring in case of achylia gastrica with diarrhea. One should be extremely careful of making a diagnosis of atypical patterns in diarrhea conditions.

in the region of the constriction, intermittent in character, often nausea and anorexia. A history of partial attacks of obstruction is usually obtained.

It is obvious that adhesions of all 3 types may exist in the same patient. We present *x*-ray films illustrating the various types. The attached legends give an epitome of the case history.

We emphasize that operative interference is not advised unless the clinical history is clear. Concise statements may be difficult to elicit in a psychotic individual, but we are confident that this procedure will rescue many patients who are diagnosed as suffering from a postoperative neurosis.

OPERATIVE TECHNIC

Spinal anesthesia is of extreme importance, inasmuch as it produces perfect relaxation of the intestine and the collapsed gut is easily handled, thus preventing trauma.

At operation the terminal ileum is identified near the ileocecal valve and it is carefully followed back toward the jejunum and the abnormal attachments dissected free. Any eviscerated loops are carefully covered with moist gauze sponges made from cotton of fine weave. The bowel is always manipulated with the utmost gentleness and respect for its property of producing an inflammatory exudate which results in agglutination of the peritoneal surfaces of the loops. The abdomen is then closed without drainage, care being taken to place the omentum between the intestine and the abdominal wall to prevent them from becoming adherent.

The postoperative treatment is of extreme importance. We must avoid every thing that might incite peristaltic movement of the small intestine. During the first seventy-two hours after operation the following rules must be rigidly enforced.

1. No food or water is given by mouth. Frequently moisten the tongue and lips with cold water.

2. The patient is sustained by the free use of intravenous glucose and saline solution.

3. No vomiting is permitted. The Levin intranasal catheter is kept in the stomach and the contents syphoned until all danger from accumulation of gastric secretion is over.

4. No enema or passage of the colon tube is permitted.

5. No laxative is given.

The patient is kept under the constant influence of morphine. It is given hypodermatically by the overlapping method, i.e., every four to six hours in doses sufficient to produce mental calm and physical rest. The dosage will vary from one-twelfth to one-fourth grain. Care must be exercised that the patient does not emerge from the morphia influence until the seventy-two hour period has elapsed. After this time the usual symptomatic treatment is employed.

CONCLUSIONS

1. Adhesions of the small intestine that give symptoms can as a rule be detected by careful roentgen examination.

3. Relief may be obtained by surgical operation and strict observance of a postoperative regime.

3. X-ray films are shown illustrating the diagnosis and differential diagnosis of adhesions, with abstract of case records.

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PATHOLOGICAL FRACTURES IN PRIMARY BONE TUMORS OF THE EXTREMITIES*

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PATHOLOGICAL fracture is a frequent complication of a primary bone tumor of the long bones. In many cases fracture is the first symptom that leads the patient to seek medical advice. And yet aside from isolated case reports and a few brief communications, there is a striking lack of recent literature on this important subject.

The earliest exhaustive work on pathological fractures is that of von Brüns in his "'Lehre von den Knochenbruchen" published in 1886. Grunert reviewed the literature from 1886 to 1904 and his monograph is excellent; his classification of pathological fractures is comprehensive; and search of the recent literature fails to disclose any contributions that compare with his work, although Eisendrath in "Keen's Surgery" has an excellent survey of the subject.

Grunert emphasizes the rarity of pathological fractures due to metastatic sarcoma; he found but two examples in the literature. He mentions the fact, which is brought out by our series, that fracture is frequently the first thing that makes us appreciate a long-standing disease of the bony system. He quotes von Burckhardt who maintains that in cases of pain in the hip of unexplained etiology followed later by fracture one should be wary of assuming that the condition is a disturbance of the nervous system.

Grunert wisely observes that there are too many examples in the literature where fracture is the first sign of the disease and that an important indication as to the nature of the disease is afforded by the fact that as a rule a pathological fracture when the result of a malignant tumor rarely unites.

Grunert has the following to say regarding union of pathological fracture due to bone sarcoma:

> As Cornil and Ranvier have shown, new osteoid tissue may be formed. Yet this will seldom lead to the formation of callus. If a mass seems to form between the ends of the fracture, it is usually destroyed just as rapidly. As a rule then the destruction of callus formation is immediately resumed, but not always. At times a true union seems to take place and may exist for considerable time. Bruns cites 4 cases where beginning union was shown by section.

Grunert found three other examples; one, a case reported by Vernuil, which occurred in a patient whose fracture was through the left lower leg and in which union took place after the pathological fracture and existed for over a year; the other 2 cases, reported by Desprès, were cited by Picqué. The first was a fracture of the femur associated with sarcoma; the fracture united and the patient lived for a year. The second was a fracture following very slight trauma involving a very aggressive tumor. Notwithstanding, union took place one month later and one month thereafter a second fracture, followed by consolidation, occurred.

The following observations of Grunert are of sufficient importance, despite the fact that they were made twenty-five years ago, to warrant quoting in full.

> While we must proceed at once to an amputation of the extremity in cases of pathological fractures due to sarcoma, it would be a mistake in cases of carcinoma, since the patient is already doomed to die, and it would force him to undergo the loss of a limb in his last days. We are justified in saying that in carcinoma, that is to say, true carcinomatous metastasis,

* From the Department of Bone Sarcoma, Memorial Hospital, Service of Dr. William B. Coley.
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union of the fragments can never occur. Up to this time there has never been a reported case of such a recovery. Isolated examples of bone fragility in carcinoma really belong to our group No. 2, where the fragility does not follow the local disease, but is a constitutional diathesis—a generalized bone atrophy. One finds, therefore, no traces of carcinomatous cells at the site of fracture. In rare cases it is possible perhaps that a fracture may unite. This is how I account for the case of von Richet (cited by Picqué) which was that of a woman who broke her lower leg as she was about to step into a carriage. No trace of tumor could be found. A short time later the patient showed Richet a small ulcerating cancer of the breast. In the meantime the fracture had been uniting slowly for two months. The etiology of the fracture was clear. It was doubtless an example of breast cancer; yet the course of the fracture proves that it was not due to a local pathology in the bone structure, but concerns itself with a constitutional tendency. Von Bruns gives three other cases which were confirmed by pathological sections.

Codman, in 1921, in a brief summary of the subject deals in particular with fractures occurring in primary bone sarcomata. His article, though brief, is replete with useful information and is based on his early experience as Registrar of the Special Committee on Bone Sarcoma of the American College of Surgeons. Aside from these authors, most of the recent literature consists of isolated case reports which do not permit of general conclusions. Among these may be mentioned Gessner, Noon and Karp. Gessner lists 2 cases of fracture following an especially violent injury. In both cases immediate *x*-rays showed fracture and in neither case was there any suspicion of malignancy until after the lapse of some weeks. It was only when symptoms of pain in one case and swelling in the other became prominent that subsequent *x*-rays were taken. These showed unmistakable evidence of malignancy at the site of fracture. This brings up the question of whether these cases represent fracture followed by the development of sarcoma or preexisting sarcoma with pathological fracture. A second study of the original *x*-ray films in each case was made and the roentgenologist reported that there was osteoporosis and thinning of the cortex sufficient to justify the opinion that disease existed at the time of fracture in both cases, although admitting that no tumor appears in the early pictures. No comment whatever as to the existence of bone pathology other than fracture was reported in the original *x*-ray diagnoses. The violence in 1 case consisted of a fall from a horse resulting in a comminuted fracture of the femur; and in the other case the patient was struck on the arm by a street car and sustained a fracture of the humerus. In conclusion. Gessner believes that the *x*-ray evidence should be paramount and that both of these cases represent pathological fracture through diseased bone rather than fracture through healthy bone followed by the development of sarcoma. The former view undoubtedly is more in keeping with current opinion, but there are unquestioned examples of the development of sarcoma following fracture through perfectly normal bone.

William B. Coley has observed 6 cases in which the sarcoma developed at the site of a recent fracture. In each instance *x*-rays taken immediately after the fracture showed no evidence of a pathological condition of the bone and yet the sacroma developed at a varying interval thereafter. In his opinion, these cases are proof that the sarcoma developed after the fracture.

Bloodgood has reported 3 cases which he regards as rare examples of the formation of a sarcoma at the site of a fracture, and Codman has a similar case.

The ratio of pathological fractures to all fractures has been obtained by Rassieur, who studied the records of a St. Louis hospital and found 588 fractures with 5 pathological fractures, or almost 1 per cent. Of these 5 cases, one was due to chronic osteomyelitis; one to bone syphilis; one to infiltrating epidermoid carcinoma of the leg; one to metastatic carcinoma of the breast and one to primary osteosarcoma. Thus but one pathological fracture

due to a primary bone tumor was found in 588 fractures, or .17 per cent. According to Bloodgood, pathological fracture occurs in 12 per cent of benign and malignant bone tumors considered together. In his records there were 9 fractures in 144 cases of giant-cell tumors and 25 fractures in 287 cases of primary bone sarcoma. He gives the percentage of pathological fracture in myeloma as 25.

This study is based on a series of 185 cases of primary bone tumors of the extremities of which 42 were complicated by pathological fractures. The cases were collected from the Bone Sarcoma Department of Memorial Hospital over a ten-year period (1919–1928).

We have not considered metastatic bone tumors in this study. Furthermore, we have limited ourselves to pathological fractures due to primary bone tumors in the long bones of the extremities, because they occur more frequently and are of more importance in the treatment and prognosis than those arising in other portions of the skeleton. Emphasis is placed on the effect that pathological fractures have on the duration of life and on the care of the patient after the occurrence of the fracture.

The diagnosis is based on the clinical, *x*-ray and histological findings in 114 cases; in the remaining 71, it rests on clinical and *x*-ray findings, which appear to us to be conclusive. It has been shown by Putti and others that clinical history, careful examination and *x*-ray studies are sufficient in the majority of cases to form an accurate diagnosis in primary tumors of the long bones. Cases have been excluded in which the records are practically deficient or lacking in essential data. Otherwise they represent unselected cases.

Osteogenic sarcoma was not separated into sub-types. It is the most frequent with 65 per cent of the total number of cases. It should be remembered, however, that prior to 1924 Ewing's tumor (endothelial myeloma) was not diagnosed as such and undoubtedly a few cases of this type may be included in the osteogenic group.

Giant-cell tumor is next in frequency, with 19 per cent, and endothelial myeloma least with 14 per cent, as shown in Table 1.

Table 1

	Total No.	Percentage Frequency, Per Cent	Total No.* of Fractures	Percentage of Fractures, Per Cent
Osteogenic sarcoma.....	122	65.9	26	21.3
Giant-cell tumor.....	36	19.5	9	25
Endothelial myeloma	27	14.6	7	25.7
Total.....	185		42	22.7

* Eight cases in small bones of hands and feet are not considered.

There are 42 fractures in the 185 cases of all types, or 22.7 per cent. The incidence of fracture is strikingly uniform in the three types of tumor. Endothelial myeloma shows a slightly greater tendency to fracture but not as great as might be expected from a consideration of its pathology, for it is characterized by bone destruction, often widespread, and by little, if any, new bone production. Fractures in giant-cell tumors are next in frequency. Here again we are dealing with a central tumor, chiefly osteolytic. Osteogenic sarcoma has a fracture incidence of 21.3 per cent with 26 fractures in 122 cases. As might be anticipated, the majority of fractures occurred in the medullary tumors, most of which were of the telangiectatic variety.

Figures were supplied us from the Bone Sarcoma Registry through the courtesy of Dr. Bowman C. Crowell, registrar, which showed a similar relative frequency of fracture in the three types of tumor, but the ratio in all of the fracture cases to total tumor cases is much lower. The figures of the Registry are as follows: osteogenic sarcoma, fracture in 7.73 per cent; giant-cell tumor, fracture in 6.36 per cent, and endothelial myeloma, fracture in 4.26 per cent. The marked difference in the Registry cases and in our own series is difficult to explain. It may be that surgeons have often

neglected to inform the Registry of the development of a fracture in cases they have previously reported. Moreover, their series comprises sarcoma of all bones, whereas ours is confined to long bones and it is well established that the latter are far more prone to undergo pathological fracture. Another reasonable explanation of the higher percentage of pathological fracture in our series lies in the fact that in the Registry cases and those in Bloodgood's records amputation probably occurred earlier than in ours, where *x*-ray and radium were given an extended trial.

CLASSIFICATION OF PATHOLOGICAL FRACTURES

I. Fractures due to Primary Tumors of Bone
  A. Benign.
    1. Osteitis fibrosa cystica (bone cysts, fibrocystic diseases of bone)
    2. Osteitis deformans (Paget's disease)
    3. Benign giant-cell tumor
    4. Enchondroma, myxoma, etc.
  B. Malignant.
    1. Osteogenic sarcoma
      a. periosteal
      b. sub-periosteal and medullary
      c. telangiectatic
      d. sclerosing
      e. fibrosarcoma
      f. atypical—unclassified
    2. Myeloma
      a. endothelial myeloma
      b. plasma cell myeloma
      c. myelocytic
      d. lymphocytic
      e. erythroblastic
    3. Liposarcoma

II. Fractures due to Metastatic Tumors.
  A. Osteogenic sarcoma (primary in another bone).
  B. Endothelial myeloma.
  C. Carcinoma { prostate, thyroid, kidney, breast, etc.

III. Fractures due to Inflammatory Processes.
  A. Pyogenic osteomyelitis (suppurative (non-suppurative
  B. Tuberculosis of bone.
  C. Syphilis of bone.
  D. Echinococcus disease of bone.

IV. Fractures due to Constitutional Bone Changes.
  A. Old age.
  B. Atrophy of disuse.
  C. Chronic wasting diseases.
  D. Rickets and osteomalacia.
  E. Scurvy.

V. Miscellaneous.
  A. Aneurysm.
  B. Brodie's abscess.
  C. Idiopathic bone fragility.

Age: The age incidence in the series we have studied conforms closely to the figures reported by other observers. (See Table II.) The average age of osteogenic sarcoma without pathological fracture was 23.7 years; with fracture it was 37.1 years. Giant-cell tumors averaged 33.0 years in cases without and 31.3 years in cases with pathological fracture. In the endothelial myeloma group the average age of cases without fracture was 18.7 years, while with fracture it was 38.2 years. Christensen, in a classification of 1000 cases of bone tumors found that the incidence of osteogenic sarcoma reaches its height at fifteen years and declines rapidly thereafter; while giant-cell tumors are most common in the third decade of life. Endothelial myeloma, he found most common in early life, more than half occurring before the age of twenty.

TABLE II
AGE INCIDENCE

	Without Fracture (Years)	With Fracture (Years)
Osteogenic sarcoma.....	23.7	37.1
Giant-cell tumor.....	33.0	31.3
Endothelial myeloma.....	18.7	38.2

In attempting to explain the later onset of the osteogenic and endothelial myeloma cases which were associated with pathological fracture, we raise the question whether the reaction of the bone to the invading tumor may not be different in the younger subjects, just as bone repair after fracture is far more rapid, and often more extensive, in young, than in older individuals. Or may it be due to a predilection of the central type of subperiosteal and medullary, or telangiectatic osteogenic tumors for patients past the average age for the whole group. This latter hypothesis, however, fails to account for the higher age incidence in the endothelial myeloma cases with fracture.

The age incidence of giant-cell tumor, both with and without fracture, is so similar that it seems to have no influence; this may be due to the fact that there is much less variation in the period of onset, it being far more frequent in the third and fourth decades.

Fig. 1. Osteogenic sarcoma with pathological fracture lower end of femur; woman of 33; radium and *x*-ray therapy; amputation, 1924; alive and well March, 1928.

Fig. 2. Telangiectatic osteogenic sarcoma with pathological fracture shaft of humerus boy of twelve; *x*-ray therapy; amputation, December, 1922; alive and well six years and six months.

Sex: As has been pointed out by others, osteogenic sarcoma is more frequent in males than in females; in this series there were 74 males and 47 females; giant-cell tumors affect the sexes about equally, there being 19 females and 15 males; endothelial myeloma is much more frequent in the male sex, there being 21 in males and 6 in females, which corresponds roughly to Christensen's findings in a larger series.

We find little to suggest that sex playsa part in the development of a pathological fracture in cases of osteogenic sarcoma or endothelial myeloma. On the other hand,

out of 9 pathological fractures in the giant-cell tumor group, 8 occurred in women, a fact we are unable to explain.

occurring in 28.1 per cent of the cases, as opposed to 18 per cent in the lower extremity. It would seem, therefore, that

Fig. 3. Telangiectatic osteogenic sarcoma of femur with pathological fracture in a girl of six years. Amputation—death from pulmonary metastasis.

Fig. 4. Endothelioma of shaft of femur with pathological fracture man of 20; *x*-ray therapy; toxins, amputation; death from pulmonary metastasis.

Location of Tumor: Considering the three types of tumor separately, we found that the location followed closely the sites of predilection that have become well known as a result of the studies of earlier observers. Table III shows in detail the total number of cases of each of the types of tumor occurring in each bone and in the portion of the bone; in addition, the small numbers represent the number of cases with pathological fracture.

Three-fourths of the primary bone tumors in this series are found in the bones of the lower extremity. Fracture is relatively much more common as a comp ication of tumors of the upper extremity, weight-bearing does not play an important rôle in the occurrence of fracture. The high proportion of all tumors of the upper extremity that are situated in the proximal

Table III

Location of Tumor and Fracture

	Femur			Tibia			Fibula			Humerus			Radius			Ulna		
	P.	S.	D.	P.	S.	D.	P.	S.	D.	P.	S.	D.	P.	S.	D.	P.	S.	D.
Osteogenic sarcoma	18	6	39	21		4	4	2	1	20	1	4	2					
	7		8	3						6			2					
Giant-cell	2		10	12			3			3	1	2			3			
	2		2	1						3					1			
Endothelial myeloma	4	5	2	2	2			3		4	2		2				1	
	1	1						1		3	1							

Note: Large numbers, total tumor cases. Small numbers, cases with fracture. *P*, Proximal end; *S*, shaft; *D*, distal end.

end of the humerus (30 out of 45) may be an important reason for this high incidence; especially since 12 of the 16 pathological fractures of the upper extremity occurred in tumors of the proximal end of the humerus. It would appear from a study of the mechanics of the upper extremity that this point is subjected to greater stress than any other. We were struck by this high rate of fracture in the upper part of the humerus and submitted our theory to Codman, who was kind enough to write as follows.

When you consider that the arm is a lever which has its fulcrum at the shoulder joint and that the power to abduct is applied on a relatively very short lever, namely from the attachment of the supraspinatus to the glenoid and from the deltoid attachment to the glenoid, you see what a great stress is put on the humerus in this region. Yet we lift our arms unconscious of their weight, although they may weigh five to ten pounds. When a small object is held in the hand, which is at the end of the long lever, the stress at the attachment of the deltoid and supraspinatus must be greatly increased. The humerus does not develop an extremely thick cortex like that of the femur because the arm is little used in weight bearing. Tumors of the humerus are particularly common at the deltoid tubercle and in the spongy bone beneath the supraspinatus attachment and it is no wonder that fracture occurs at this point.

Interval between Onset of Symptoms and Fracture: The initial symptom was referable to fracture in approximately one-fifth of all the cases (9 out of 42, or 21.4 per cent). (See Table IV.) Symptoms preceded the fracture in all the endothelial myeloma group. Pathological fracture initiated the first symptoms in 5 of the 9 cases of giant-cell tumor. In the five with simultaneous onset of symptoms and fracture, two occurred while walking and one while doing down stairs resulting in sudden collapse and pain; the fourth followed a fall on the ice and the fifth was caused by a blow from a crank handle. Three of these were spontaneous and two followed trauma. Tumor was definitely demonstrated by examination and *x*-ray immediately following the fracture in these cases.

TABLE IV
FRACTURE AS INITIAL SYMPTOM

	Fracture with Onset of Symptoms No. of Cases	Fracture Following Onset of Symptoms	
		No. Cases	Average Months
Osteogenic sarcoma.....	4	22	12.2
Giant-cell.....	5	4	3.8
Endothelial myeloma.....	0	7	7.8

In the osteogenic sarcomas, 4 of the 26 patients dated their trouble from the time of fracture. One boy was throwing a ball; another was skating and suddenly collapsed; a third fell from a ladder, sustaining a fracture; and the fourth fell and also sustained a fracture. Two were spontaneous pathological fractures and 2 followed trauma. The 2 spontaneous fractures were in rapidly growing tumors and the pathology showed that 1 was of the periosteal type and the other medullary. Histological material was not obtained in the 2 traumatic cases.

Where fracture occurred after the beginning of symptoms, the average interval between first symptoms and fracture was about one year in the osteogenic sarcoma, four months in the giant-cell tumor and eight months in the endothelial myeloma group.

Symptoms of Pathological Fracture: The symptomatology in this group coincides with the typical textbook descriptions. As shown here, an average of one year elapsed before fracture in the osteogenic group. This is a very rough estimate, as one fibrosarcoma was present five years before fracture. The different types, therefore, vary greatly in their interval period between onset of symptoms and fracture. These estimates for giant-cell tumor and endothelial myeloma represent a truer sequence of events.

Types of Fracture: Fractures may be either complete or incomplete. In the

early stages they are often incomplete and are picked up solely from a study of the *x*-ray films; many of these become complete as further bone destruction takes place. They may occur as compression fractures, due to the buckling caused by weight-bearing. This type is not unusual in giant-cell tumor of the upper extremity of the tibia or lower extremity of the femur. They commonly occur as "rotten-wood" fractures due to progressive involvement of the entire thickness of the bone. These are often seen in endothelial myeloma and in the medullary, or subperiosteal and medullary osteogenic sarcoma of the shaft of the bone. Fractures may be with or without displacement; but displacement is greatly hampered by the presence of the tumor tissue about the site of fracture, so that marked over-riding is unusual. Except in the case of fractures occurring in giant-cell tumor and benign cyst (osteitis fibrosa cystica), there is seldom much shortening for the same reason. Certain of the medullary tumors may fracture subperiosteally with, however, later tearing of, or invasion of the periosteum as the destruction of bone goes on apace and the mechanical factors responsible for the fracture continue to operate. Pulsation of the tumor at the site of fracture has been observed. It is sometimes seen in the malignant bone aneurysm (telangiectatic osteogenic sarcoma), angioendothelioma and vascular metastatic tumors of the thyroid.

Fig. 5. Angioendothelioma of tibia and fibula with pathological fracture; man of 28; *x*-ray; toxins; amputation, June, 1926; pulmonary metastases present at time of amputation; alive and working; symptom free June, 1929—three years and six months after amputation.

Differential Diagnosis: It is undoubtedly difficult to make a correct diagnosis of the underlying cause of a pathological fracture in a certain percentage of cases. This difficulty, inherent in the diagnosis of bone tumors and associated conditions, is enhanced by the alteration in the *x*-ray picture which is produced by the fracture. The age of the patient, the location of the tumor, the presence or absence of symptoms (and their duration) prior to the fracture, are important and should be considered in conjunction with the *x*-ray films. The latter should include not only several views of the site of fracture but also the lungs and other bones of the skeleton.

It is a point worthy of mention that late films after much bone destruction has taken place and where a pathological fracture has further altered the typical appearance would make it very difficult to distinguish between a giant-cell tumor and a malignant bone aneurysm (telangiectatic osteogenic sarcoma). Previous operation may so alter the *x*-ray appearance as to lead to diagnostic difficulties.

The physical examination should include a careful investigation of the possible sources of carcinoma which is prone to

metastasize to bone (kidney, breast, thyroid, prostate, etc.).

Within the past year 4 cases of unsuspected hypernephroma with bone metastasis have been referred to the Bone Department of Memorial Hospital. This type of metastatic bone carcinoma may closely simulate the angioendothelioma primary in bone; and even the histological diagnosis between these two conditions is difficult.

Bone syphilis is sometimes associated with a pathological fracture. Gratz has recently reported a case in which the radiological diagnosis of osteitis fibrosa cystica was made. The Wasserman test was also positive. Firm union occurred within seven weeks under *x*-ray and antiluetic treatment.

A boy of thirteen was seen with a pathological fracture of the neck of the femur due to osteitis fibrosa cystica; he was referred from another hospital as a case of sarcoma. Another case was seen with a similar lesion in the same location, and a third case in which the humerus was the seat of three successive pathological fractures, each of which was promptly followed

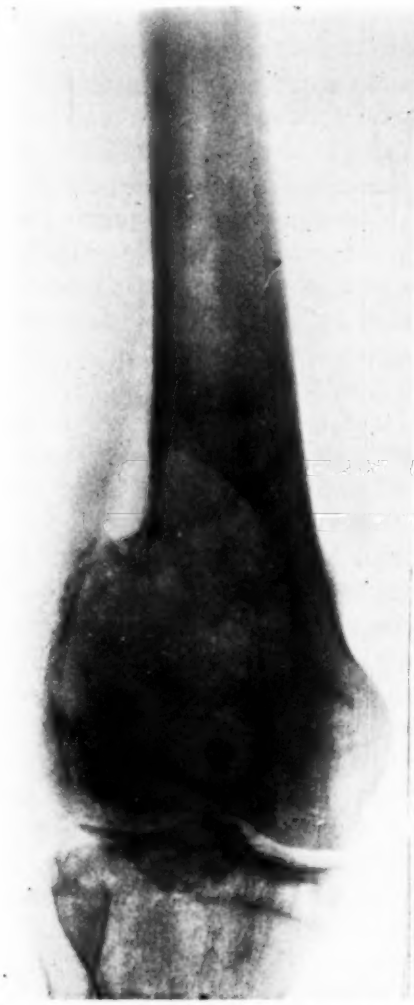

Fig. 6. Giant cell tumor with compression fracture of distal end of femur; woman 37. Curettage; radiation; amputation; alive at present—2½ years later.

Fig. 7. Atypical giant cell tumor; prolonged *x*-ray therapy; pathological fracture with limb in position of marked flexion deformity; amputation October, 1927; free from disease at present.

by union. This condition is sufficiently frequent to warrant its being considered in pathological fracture in adolescents.

As to the question of distinguishing between the three principle primary bone tumors, it may be said that mistakes will occur even where the closest attention is paid to the history, clinical findings and *x*-ray features, though these constitute a minority of all cases. The importance of the evidence obtained by a careful study of adequate *x*-ray films cannot be overemphasized.

Treatment of Pathological Fractures: In considering the treatment, both the bone tumor and the complicating fracture require attention. The variety of tumor influences the treatment, since it is essentially different.

Prevention of Pathological Fractures: Since pathological fracture so greatly contributes to the distress of the sufferer and to the difficulties in managing the treatment of the case, great care should be taken to avoid it, or postpone it as far as possible. It seems quite illogical to treat cases of malignant bone tumors, especially of the lower extremity, as ambulatory. Prolonged immobilization in cases that are being treated with *x*-ray and radium is an important part of the treatment. In many instances, owing to lack of bed space, this has not been possible. In giant-cell tumors, the prognosis for saving a limb with useful function after pathological fracture has been in our experience quite favorable. In this type of tumor, however, the aim should be to institute treatment early and protect against any trauma that might result in a fracture.

Treatment of Osteogenic Sarcoma with Pathological Fracture: Immediate amputation well above the site of fracture is the method of choice, provided no clinical or *x*-ray evidence of pulmonary metastasis exists. This is followed by injections of the mixed toxins, both intramuscular and intravenous, as a prophylaxis against recurrence. It may be shown subsequently that postoperative prophylactic radiation of the pulmonary fields with high voltage deep *x*-ray therapy is worth while. This is now being given a trial in some cases. There is little to hope for in this type of tumor from the standpoint of postoperative radiation, owing to the lack of radiosensitiveness of osteogenic sarcoma and the depth of the pulmonary fields. Preliminary radiation prior to amputation in cases with fracture has not yielded results sufficient to warrant delay in amputation. If metastases have already occurred, amputation may still be justified to relieve the patient of a painful condition which does not lend itself to conservative treatment. Plaster splints, casts and traction suspension methods all have their individual indications.

Treatment of Endothelial Myeloma with Pathological Fracture: Here two factors present therapeutic indications quite different from the osteogenic group. The first is the now well-established fact that this tumor is particularly radiosensitive. The second is the frequency of multiple bone and lung metastases, occurring early, which makes amputation discouraging even from the standpoint of temporary palliation. It is therefore advisable to immobilize the fragments in as satisfactory apposition as possible, while radiation, preferably by combined radium pack and high voltage *x*-ray cycles, is pushed to the limit of skin tolerance. It is a clinical conviction that this tumor is also responsive to toxin treatment and this should be administered vigorously at the same time. If sufficient regression occurs and widespread metastases do not supervene a later amputation may be advisable when it becomes evident that non-union and a useless extremity will be the end-result. We have not used interstitial radiation in endothelial myeloma cases. The results of this form of radiation have not been encouraging in the few cases of osteogenic sarcoma in which it has been tried. External radiation is undoubtedly preferable.

Treatment of Giant-cell Tumors with Pathological Fracture: Here one encounters conflicting opinions and it is admittedly the group that offers the greatest difficulty in the establishment of a standardized method of treatment. In fact, each case must be considered individually and a decision reached as to the best course to pursue after all factors are weighed. In the first place, there is a considerable variation in the aggressiveness of even the benign type of giant-cell tumors of long bone, although we recognize that the majority are only locally invasive. A small but important fraction, however, will eventually metastasize to the lungs, and it is not always possible to distinguish them by clinical and *x*-ray study from those which run a benign course. Ewing believes that they can be distinguished histologically and that the typical benign giant-cell tumor never metastasizes unless it has been subjected to the trauma of an operation.

Furthermore we find occasional cases in which the clinician and the roentgenologist agree on a diagnosis of benign giant-cell tumor, but where the response to treatment fails to justify this diagnosis and later an amputation is performed and an osteogenic central tumor found.

Herendeen has demonstrated that benign giant-cell tumors may be successfully treated with *x*-ray. In some instances, control of the growth by the laying down of new bone in the tumor has been accomplished by comparatively small doses of this agent. In our early work, having no standard dosage to guide us, there is no doubt that some of these cases were over-treated. A certain proportion appeared to be favorably influenced and later developed signs of a renewed activity, requiring further radiation. A few have failed to respond from the start and have been amputated. It is reasonable to expect, however, that in the future amputation will seldom be necessary in the management of a case of benign giant-cell tumor. Giant-cell tumor complicated by fracture (and this does occur in about one-fourth of all cases) should be treated by immobilization in the best anatomical

Fig. 8. Osteitis fibrosa cystica of upper extremity of femur; pathological fracture; union with deformity subsequently corrected by osteotomy.

alinement of the fragments that is obtainable, during the period when exposure to *x*-ray treatment is taking place. In a large proportion of these cases a pathological fracture will unite under treatment. Even after union has begun to take place prolonged protection by splints (ambulatory Thomas, etc.) is advisable.

A convenient method of immobilization is afforded by the use of circular plaster casts which have been bivalved, permitting removal for exposure to *x*-ray or radium and immediate replacement until such time as another treatment is indicated.

After sufficient time has elapsed to permit deductions as to the response of the individual tumor to *x*-ray, a decision can

be reached as to whether further trial with this form of treatment is indicated or whether some form of surgery is necessary. Curettage followed by carbolic acid or zinc chloride application has been used successfully by Bloodgood and has yielded satisfactory results in a number of instances in our hands. This method, however, has been followed by infection, failure to heal and, in some instances, fungation of the tumor tissue, and we have ample evidence that it is a procedure not without risk in the hands of the general surgeon. We believe it is never indicated in cases associated with pathological fracture. We have not been impressed with the more extensive operative procedure such as bone graft, muscle and fat transplantation and the use of bone chips in the cavity.

Prognosis: It is difficult to estimate the influence of a pathological fracture on the prognosis of a primary bone tumor of the extremities. It is demonstrable from a study of this series that the duration of life of the osteogenic group is definitely shortened. Whether this is due to the fact that in those cases in which fracture occurs there is a more rapid rate of tumor growth or whether by virtue of the fracture greater opportunity is afforded for early dissemination of the disease cannot be stated definitely. As shown in Table v in the cases with fracture, death occurred on an average of ten months earlier than in the cases in which there was no pathological fracture.

The endothelial myeloma group is composed of too small a number of cases of fracture to make trustworthy deductions as to the influence of fracture on the duration of life.

In the giant-cell group there was no mortality in cases with fracture. The period of active treatment, however, was considerably prolonged and the end-result definitely less favorable in those associated with pathological fracture.

Union after Pathological Fracture: There is some difference of opinion as to the frequency with which pathological fracture due to primary bone tumor unites. Bloodgood states that healing of a pathological fracture in primary bone sarcoma occurred twice in 25 fractures. William B. Coley reports 2 cases of endothelial myeloma of the humerus in which under toxin and radium treatment the pathological fracture healed. One of the patients is well five years later with full restoration of function; and in the other, a more recent case, the fracture united in four weeks under the same form of treatment and the patient is well six months later.

TABLE V
DURATION OF LIFE IN PATIENTS WITH OSTEOGENIC SARCOMA

	Onset to Death Average Months	Not Traced (Cases)	Still under Observation (Cases)
Non-fracture cases.	23 (59 cases)	15	13
Fracture cases.....	13.8 (14 cases)	4	8

Giant-cell cases, all alive.
E. M. cases, series too small to base accurate conclusions as to influence of fracture on duration of life.

In the giant-cell tumor cases with pathological fracture 7 of the 9 achieved union. Four of these were located in the femur. They were all followed for periods ranging from five to eight years and were free from disease. Of the two remaining, one was traced only one month and the other was amputated for a recurrence following curettage and *x*-ray therapy.

Of the 7 cases of endothelial myeloma with fracture, firm union was obtained in 3. Two were amputated and non-union persisted until death in 1 case and in the remaining case there were no later notes about the condition of the fracture. Excluding this latter case and the 2 that were amputated, it would appear that in 3 of the 4 remaining cases union occurred.

Conclusions: 1. Pathological fracture occurred as a complication in 22.7 per cent of a series of 185 primary bone tumors of the extremities. Divided into types, fracture occurred in endothelial myeloma in 25.7 per cent; in giant-cell tumor in

25 per cent and in osteogenic sarcoma in 21.3 per cent.

2. Pathological fractures are most likely to occur in patients past the average age for the corresponding tumor.

3. Three-fourths of the tumors occurred in the lower extremities.

4. Pathological fractures are most common in the upper extremity and the upper end of the humerus was the region of greatest susceptibility to fracture (12 out of 16 cases), an explanation for which is offered.

5. In this series of 42 fractures, tumor preceded fracture in every instance.

6. Fracture was the initial symptom in one-fifth of all cases; it did not occur as an initial symptom in any of the endothelial myeloma cases.

7. The life expectancy of a patient with osteogenic sarcoma in whom pathological fracture has occurred is shortened 60 per cent.

8. All the patients with fracture in giant-cell tumor are living one to eight years.

9. Fracture increases the difficulty in handling cases with primary bone tumors, especially ambulatory treatment with *x*-ray and radium.

10. Fracture was followed by union in 3 of the 7 cases of endothelial myeloma; in 7 of the 9 cases of giant-cell tumor; and in none of the 26 cases of osteogenic sarcoma.

11. Pathological fracture may be postponed or even prevented entirely by early and continuous support.

12. The failure to immobilize a limb in which a pathological fracture has already occurred may predispose to early dissemination.

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DIAGNOSTIC NOVOCAINE BLOCK OF THE SENSORY AND SYMPATHETIC NERVES

A METHOD OF ESTIMATING THE RESULTS WHICH CAN BE OBTAINED BY THEIR PERMANENT INTERRUPTION*

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DURING the past year a method has been developed on the Surgical Services of the Massachusetts General Hospital to determine the benefit of proposed operations for pain and circulatory disease. This test shows the surgeon who is planning an interruption of the cerebrospinal nerves or the resection of sympathetic ganglia just what the contemplated operation can accomplish in the way of relief of obscure pain or increasing peripheral circulation. This can be accomplished by the use of regional anesthesia, which has now reached such a perfection of technic that almost any important nerve in the body can be selectively blocked.

The pioneer in the use of novocaine for determining the pathways of obscure pain was Von Gaza.[1] His work has received little recognition in this country, but it is being carried on and amplified by Leriche in Strasbourg[2] and by Archibald[3] and Scrimger[4] in Montreal. The purpose of this paper is to point out the great value of the preliminary injection of novocaine in localizing the cerebrospinal or sympathetic trunks which are carrying painful stimuli. A second very useful application of this method has been recently developed in the Circulatory Clinic at the Massachusetts General Hospital,[5] a test to estimate quantitatively the increase in peripheral circulation which will follow sympathectomy.

The technic of injecting the main nerve trunks to the extremities, the spinal nerves, and the sympathetic rami and ganglia is beyond the scope of this paper. It has been very well described by Labat.[6] I have used this procedure diagnostically in a series of 29 cases with only a single misleading result. (Table 1.)

I. DIAGNOSTIC NOVOCAINE BLOCK TO DETERMINE THE PATHWAYS OF VISCERAL PAIN

Ranson[7] has shown histologically that sensory fibers run in the sympathetic nerves and enter the spinal cord through the white rami of the dorsal and upper lumbar region. Whether these are true sympathetic or cerebrospinal fibers is as yet undetermined; but it is a point of purely academic interest, because there is now not the slightest question that interruption of the white rami can relieve pain of visceral origin. That sensory fibers from the heart, aortic arch and lungs run to the cord through the upper five to six thoracic rami has been proved through paravertebral injection by Mandl,[8] Swetlow,[9] Mixter and White.[10] Laewen[11] has shown by infiltrating novocaine around the lower thoracic and upper lumbar white rami in patients suffering from severe abdominal pain, that the sensory fibers of the upper abdominal viscera run in the splanchnic nerves and enter the cord in the following segments.

Esophagus.....	D_5–D_6
Stomach.....	D_7–D_8
Gall bladder....	D_{10} (right)
Small intestine..	D_9–D_{10}
Kidneys.....	D_{12}–L_1
Appendix.....	L_1–L_2 (right)

The large majority of patients suffering from visceral pain are of course relieved by proper treatment of the diseased organs. Nevertheless, there are frequent

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TABLE IA
NOVOCAINE BLOCK TO TEST EFFECT ON THORACIC AND ABDOMINAL PAIN

Case	Disease	Injection	Result	Temperature	Operation	Success
I	Painful metastatic cancer of sternum.	Intercostals 2–4 (right)	Showed number of intercostal nerves to be cut.		Cutting intercostals 2 to 4	Yes
II	Tabes with crises.	Thoracic D_4–D_7 Gastric D_7–D_{11}	Stopped thoracic crises for a day. Stopped gastric crises for 36 hrs.	+ 3° o	Ramisectomy D_4–D_7. Resection splanchnic nerve D_7–D_{10} ganglia.	Yes
III	Severe right upper quadrant pain with congenital lesion 10th dorsal vertebra.	D_{10}	Pain disappeared for 4 hours.		Alcohol injection D_1	Yes
IV	Aneurysm ascending aorta.	D_1 and D_2 (right)	Stopped pain for 36 hours.		Alcohol injection D_1–D_2	Yes
V	Angina pectoris.	D_1 and D_2 (left)	Excision of these ganglia should stop attacks.		Resection of stellate and D_2	Yes
VI	Carcinoma lung and pleura.	D_1 and D_4	Stopped pain for several hours.		Alcohol injection D_1–D_3	Yes
VII	Right upper quadrant pain after multiple operations. Cause unknown.	D_{12}	Pain disappeared for 3 hours.		Resection of D_{12} ramus.	Yes

instances when the disease itself is incurable, where the patient can be made tolerably comfortable by interrupting the pain. In other cases the suspected organs, most often the gall bladder or the appendix, have been removed but the pain has continued. In still other conditions, the painful focus apparently lies in the central nervous system, but denervation of the areas to which the pain is referred can cause it to disappear. In such obscure problems, preliminary injection of novocaine can throw much light upon the mechanism of pain and a subsequent operation can be undertaken with a definite assurance of success. It is in these baffling instances that Von Gaza's method is most useful.

CASE HISTORIES

The entire series of 29 cases is summarized in the tables, but only those of particular interest will be discussed in greater detail.

Case II. A Jewish tailor who complained of extremely painful tabetic crises of four years' duration in his left chest and abdomen, as well as in both legs. All forms of antileutic therapy had been tried without result. Section of his seventh to eleventh dorsal posterior roots had produced abdominal anesthesia to pin-prick, but had not diminished skin hyperesthesia to touch or cold, nor had it had any effect on his gastric crises. Two cordotomies, in spite of causing considerable bladder disturbance, had only produced numbness of the left leg. Paravertebral injection of novocaine from D_7 to D_{11} gave absolute relief of his abdominal pain for thirty-six hours, as well as producing a complete numbness of the skin. With this lead, Dr. W. J. Mixter resected the left splanchnic nerve with the eighth to tenth thoracic ganglia. This operation has given relief of his abdominal crises to date (six months). I have since done a similar test injection of his fourth to seventh segments to see if it would relieve the thoracic crises. As it was again successful, I have cut the corresponding rami with similarly good results.

It is interesting to note that an injection of his lumbar sympathetic trunk had no effect on the painful crises in his right leg. In another tabetic patient, injection of the posterior tibial nerve temporarily relieved a severe crisis in the sole of his foot.

Leriche[12] and Van Bogaert and Verbrugge[13] also have used this method and have concluded that sympathetic ramisection is a far better operation for gastric crises than section of the posterior roots.

Case III. A woman of forty-five, after the sudden death of her husband, developed attacks of severe lancinating pain from her right costal margin to the umbilicus. After prolonged observation, nothing abnormal had been found except a peculiar lesion of her tenth dorsal intervertebral disk. This had been declared to be a congenital abnormality by two

x-ray consultants. She was then explored and a slightly abnormal looking gall bladder removed. As a result, her previous pain became so severe that it was not controlled by 3 grains of morphine daily. Diagnostic novocaine injection of her ninth, tenth, and eleventh spinal nerves and sympathetic rami caused the pain to disappear entirely. A paravertebral alcohol injection of the tenth nerve was then performed and the pain disappeared for three months. The pain has now recurred in a milder form, so that the nerve will probably have to be cut to give her permanent relief.

Fig. 1a. Fig. 1b.

Fig. 1. Case iv with aneurysm of ascending arch of aorta. To show widespread distribution of pain and points of injection of first and second dorsal sympathetic rami.

In this nervously exhausted patient who had already been put through a major operation without relief, the novocaine test gave us an assurance that a relatively simple alcohol injection could alleviate her suffering.

Case iv. A very thick-set railroad employee of forty-nine entered the hospital with a huge aneurysm of the ascending arch of his aorta, which was bulging out between his clavicle and first rib. There was marked venous engorgement of his head and severe constant pain over the entire area shown in Figure 1. When he coughed the pain was intolerably severe. By means of paravertebral novocaine block it was demonstrated that the pain referred over this wide region could be stopped completely by blocking his first and second dorsal sympathetic rami on the right side. Alcohol injected into the same areas relieved the pain entirely until he died three months later of rupture of the aneurysm.

As this pain was referred over a large portion of his cervical and upper dorsal segments, we would have been quite in the dark as to which segments to attack without the knowledge secured by the preliminary injection of novocaine.

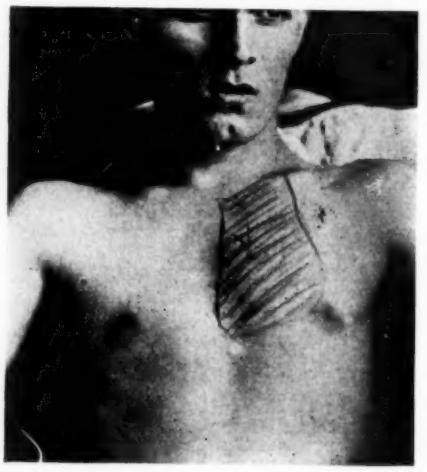

Fig. 2. Case v. Area of referred pain in angina pectoris, relieved by novocaine infiltration and excision of first and second dorsal ganglia.

Case v. A young man of twenty with rheumatic heart disease and aortic regurgitation was having up to 18 severe attacks of angina pectoris daily, with pain referred over the area shown in Figure 2. Prolonged medical treatment had not given him relief, but his general condition in other respects was good. In our clinic we feel that cervical sympathectomy is an unphysiological and unsatisfactory operation. We hoped that the patient might live for many years and were not sure that an alcohol injection would give permanent relief. Therefore, we decided to remove his upper thoracic sympathetic rami and ganglia by the dorsal approach, but were uncertain as to how many segments would have to be resected. Paravertebral novocaine block of D_1 and D_2 on the left side stopped the attacks for thirty-six hours. A subsequent resection of these two ganglia by Dr. W. J. Mixter and myself gave him complete relief from his angina for nine months, when he died suddenly with an attack of right precordial pain.

In this instance, as well as in the preceding case, we were undertaking operations which to the best of our knowledge had not been tried before. But with the information obtained from the novocaine test, we felt quite confident that they would succeed.

Case vi. A woman of sixty-two gave a five months' history of bloody sputum, weakness, dyspnea and loss of weight. For two weeks she had suffered from knife-like pains in her left shoulder and back. *X*-ray showed a large tumor in her upper chest and fluid displacing the right border of her heart 2 in. to the right of her sternum. A chest tap obtained a liter of serosanguineous transudate, but did not relieve her pain. Swetlow[14] had already shown that pain from carcinoma of the lungs and pleura could be relieved by paravertebral alcohol injection, but we were uncertain as to just how many segments needed to be blocked. Novocaine was, therefore, infiltrated in the region of the upper dorsal intervertebral foramina. When the first 4 were blocked, all the pain had disappeared. Without moving the needles, 6 c.c. of alcohol were injected into each. There was no recurrence of pain while she remained on the ward, but she has been lost track of since.

II. Diagnostic Novocaine Block to Determine the Pathways of Pain in the Extremities

Painful amputation stumps are notoriously difficult to desensitize; the same is true of causalgias and other obscure painful conditions which follow penetrating wounds, prolonged sepsis and trauma of the hands and feet. Amputation, neurectomy and even extensive section of the posterior roots have often failed to give relief. In the simpler types it is often desirable to find out which nerve trunk is carrying the painful stimuli. The following is a case in point:

Case viii. A man with thrombo-angiitis obliterans had had a Gritte-Stokes amputation. Just as he was ready for his artificial leg he had fallen and struck on the tip of his stump. This had set up severe pain of two sorts: (1) Lancinating twinges of pain in his phantom toes; (2) a steady burning ache deep down in the tip of his stump.

Novocaine injection of the sciatic at once stopped the shooting pains in his phantom toes and alcohol injection of the nerve made this permanent, but the deep pain under his patella persisted. When the anterior crural and lateral femoral cutaneous nerves were blocked, there was complete skin anesthesia of the stump, but the deep ache and tenderness still persisted and prevented his using an artificial leg. As a last resort, I did a diagnostic infiltration of his obturator nerve. The pain disappeared at once with the novocaine and has not recurred for nine months. During this period he has been bearing full weight on an artificial leg eight hours a day selling newspapers.

In this case the site of pain beneath the patella might have made us suspect the obturator nerve, but there are other types of amputation stump and traumatic neuritis which are far more difficult to treat. I recall one such case in Leriche's clinic in Strasbourg, where an ex-soldier had had 5 successive amputations starting with a crushed finger and ending with a frightfully painful stump of his upper arm. When a posterior root section had failed to help him, he came to the clinic threatening suicide if he could not be relieved. He was

finally cured by the removal of his stellate ganglion. This type of case, which may start with a relatively minor wound or trauma, is characterized by diffuse tenderness not limited to any known distribution of the cerebrospinal nerves. There is frequently an accompanying state of vasomotor spasm involving the entire extremity. Here is a rather typical case:

Case xii. A man of thirty crushed the terminal phalanx of his right index finger in a box-making machine in May, 1929. The tip of the finger was amputated and a rather poor stump resulted. He came into the hospital in October complaining of severe aching pain shooting up the inner aspect of the forearm. When it became most severe, it radiated into his right chest (Fig. 3). During the summer the

Fig. 3. Area of distribution of pain in Case xii. Relieved by novocaine infiltration and excision of first and second dorsal ganglia.

Table ib

Novocaine block to test effect on pain in the extremities

Case	Disease	Injection	Result	Temperature	Operation	Success
viii	Painful Gritti-Stokes amputation.	Femoral sciatic	Phantom foot pain and pain under patella relieved.		Alcohol injection of sciatic.	Yes
		obturator			Obturator cut.	Yes
ix	Painful Gritti-Stokes amputation.	Sciatic obturator	Relief pain for 2 hrs. (Result here misleading).		Obturator nerve cut.	No
x	Traumatic amputation of four fingers.	D_1 and D_2	Complete relief for 24 hours.		Resection of multiple neuromata in scar.	Yes
xi	Causalgia from puncture wound of hand. Vasomotor spasm.	D_1 and D_2	Complete relief for 24 hours.	+16.5°	Not severe enough for operation.	
xii	Causalgia from crushed finger. Vasomotor spasm.	Digital nerves.	No relief.	+16°	Dorsal ganglion-ectomy.	Yes
		D_1 and D_2	All pain stopped.			
xiii	Painful fourth finger (cause unknown) vasomotor spasm, hyperhydrosis.	Digital nerves.	Relieved pain in finger. Warm dry hand, pain unchanged.	+17.3°		
		D_1 and D_2				
xiv	Painful traumatic arthritis of wrist.	D_1 and D_2	All pain stopped for 5 days.		To have dorsal ganglion-ectomy soon.	
xv	Old rupture of supraspinatus tendon. Pain in shoulder.	D_1 and D_2	No effect on pain. Hand warmed.		No operation.	
xvi	Vasomotor instability with burning pain in feet.	L_1	Burning stopped.	+15.6°	Bilateral lumbar ganglion-ectomy.	Yes

hand had become moist, cyanotic and so cold that he had to wear a glove on all but the hottest days. As the cool weather came on, he found himself unable to work at all. Had the pain been due to a neuroma or any local cause, blocking the base of his finger with novocaine should have relieved it. This procedure had no effect on the ache in his arm. A paravertebral infiltration of D_1 and D_2, however, warmed his hand and stopped the pain for over twenty-four hours. As no anesthesia is produced in the arm by this injection, it proved that the sympathetic nervous system was responsible for the entire syndrome.

As this was one of the first cases in which I had tried this test, I did not dare undertake at once such a radical procedure as dorsal ganglionectomy. A reamputation of his finger through the middle of its proximal phalanx was done instead. This resulted in a very good stump, but the general condition of his hand and arm was made worse. He reentered in February, stating that in spite of a long course of baking and massage, he had remained totally incapacitated. Excision of his first and second thoracic ganglia has resulted in complete relief of all his symptoms.

Case xvi. A young Russian Jewess, who during the Revolution was exposed for long periods to extreme cold. Following this she developed chilblains in her feet which caused such burning pain that she was unable to work during the winter of 1928–29. She also showed a continuous vasomotor spasm of her hands and feet, but this bothered her very little in comparison to the pain. Before undertaking lumbar ganglionectomy, we wished to know whether interruption of the sympathetic nerves would relieve her pain as well as warm her feet. Novocaine injection of her left lumbar sympathetic trunk caused the burning pain to disappear in the injected leg for the remainder of the day besides warming the foot 15° F. She readily accepted operation; it was performed six months ago and has enabled her to work through the past winter without any further difficulty.

Table 1c

Novocaine Block to Test Effect on Circulation

Case	Disease	Injection	Result	Temperature	Operation	Success
xvii	Raynaud's disease with gangrene of two fingers.	D_1 and D_2	Cyanosis and sweating disappeared.	+11°	Dorsal ganglionectomy.	Yes
xviii	Raynaud's disease with atrophy of two fingers.	D_1 and D_2	Cyanosis and sweating disappeared.	+23.4°	Dorsal ganglionectomy.	Yes
xix	Continual vasomotor spasm four extremities. Painful edema left leg.	Spinal	Cyanosis and sweating disappeared.	+12°	Bilateral lumbar ganglionectomy.	Yes
xx	Ulcer in sole of foot. Poor circulation, sequel to poliomyelitis.	Spinal	Sweating disappeared.	+16.5°	Bilat. lumbar ganglionectomy.	Yes
xxi	Poor circulation, sequel to poliomyelitis.	Sciatic	Sweating disappeared.		No operation.	
xxii	Erythema induratum with open ulcers.	Spinal	Cyanosis and sweating disappeared.	+17.7°	Bilateral lumbar ganglionectomy.	Yes
xxiii	Thrombo-angiitis obliterans. Superimposed vasomotor spasm. Non-healing amputation of toe.	Spinal	Slow warming and improvement of cyanosis.	+12°	Lumbar ganglionectomy.	Yes
xxiv	Thrombo-angiitis obliterans. No vasomotor spasm. Non-healing amputation of toe.	Spinal	No change.	0	Amputation.	
xxv	Chronic vasomotor spasm of hands. Pain in finger tips. Early scleroderma.	D_1 and D_2	Warmed hands. Stopped pain. None.	+19.5°	Dorsal ganglionectomy.	Yes*
xxvi	Chronic vasomotor spasm of hands. Pain in fingers and wrist. Moderately advanced scleroderma.	D_1 and D_2	Warmed hands. Stopped pain. None.	+21°	To have operation soon.	
xxvii	Advanced scleroderma. Cold hands.	D_1 and D_2	No effect. Little change, arteries of fingers apparently compressed.	+ 3°	No operation.	
xxviii	Birth injury with spastic cold arm.	D_1 and D_2	No change in spasticity.	+23°	No operation.	
xxix	Compression fraction D_{12} Spasticity. Cold, ulcerated feet.	Sciatic	Hyperemia of foot.	+26.7°	Bilateral lumbar ganglionectomy.	Yes

* Too early to tell effects on fibrosis.

III. DIAGNOSTIC NOVOCAINE BLOCK TO DETERMINE THE EFFECT OF SYMPATHECTOMY IN INCREASING PERIPHERAL CIRCULATION*

In the arm, a paravertebral novocaine injection of the upper two dorsal sympathetic ganglia gives a rise in peripheral skin temperature which has consistently corresponded within a few degrees to that produced by dorsal ganglionectomy. The value of the test is illustrated by this case:

Case xvii. A woman forty-six years old had Raynaud's disease which had caused terminal gangrene of 2 fingers. The atrophy of the skin was so marked and the circulation to the fingers so poor, that there was considerable doubt as to how much improvement would take place from removal of the stellate and second dorsal ganglia. This was investigated by a novocaine injection of these ganglia, which caused a rise of 11°† in the finger tips. Subsequent operation has duplicated the increase in temperature nearly exactly.

Table II

MRS. T. VASOMOTOR SPASM 4 EXTREMITIES

	Before Paravertebral Injection		After Paravertebral Injection		Postoperative 1 Month	
	R	L	*R	L	*R	L
Tip Thumb	80.0	77.4	91.0	83	92.0	80.8
Dorsum Hand	84.0	87.0	91.0	88	91.3	82.9
Mid. F. A	88.4	88.9	93.4	92.6	95.0	89.6
Room	74		75		73	

In the case of the legs, the effect of interrupting the vasomotor pathways can be determined in three ways, by:

Spinal subarachnoid block.

Injection of the lumbar sympathetic ganglia.

Peripheral nerve block.

1. *Spinal Subarachnoid Block.* In any spinal anesthesia where numbness rises to the xiphoid, all the sympathetic nerves to the lower extremities are temporarily paralyzed. As a result the legs become flushed, dry and hot. This reaction lasts as long as the anesthesia. Spinal block has proved most useful as a quantitative test for showing the increase in peripheral surface temperature which will follow lumbar ganglionectomy.

Case xx. In a boy of sixteen, who had had poliomyelitis eleven years before, an attempt had been made to straighten out a bad claw foot deformity by manipulation with a Thomas wrench and fixation in a plaster boot. When the plaster was removed a deep ulcer had developed on the ball of his foot. Attempts at skin grafting had failed. As the foot was continuously cold and discolored, it was very important to know whether the circulation could be increased by lumbar ganglionectomy. Spinal anesthesia was given and five minutes later the temperature of the toes had risen from room temperature of 78° to 95°. The operation was performed under the same spinal anesthesia and resulted in a permanently hot foot. The ulcer was subsequently grafted and has remained healed.

Case xxiii. In a case of thrombo-angiitis obliterans, where the big toe had been removed for gangrene, the amputation stump had failed to heal. Intravenous injection of foreign protein, as recommended by Brown[15] had failed to increase the peripheral circulation. Before we considered a reamputation, however, a diagnostic spinal anesthesia was given. The skin temperature at the base of the ulcer rose slowly 12°. Although it required forty minutes to do this, the increase in temperature was reproduced exactly by excision of his second to fourth lumbar sympathetic ganglia and the ulcer was slowly healed.

2. *Injection of the Lumbar Sympathetic Ganglia.* Posterior splanchmic block also produces an increase in surface temperature of the legs which corresponds closely to the results obtained by ganglionectomy. As the spinal anesthesia test is simpler, we block the sympathetic trunk only when we wish to know the effect on pain as well as temperature (see Case xvi).

3. *Peripheral Nerve Block.* Blocking the peripheral nerves produces a maximum

* The technic and results of diagnostic novocaine block for determining the effect of ganglionectomy in cases of peripheral circulatory disease are given in detail in another publication.

† All temperatures are given in degrees Fahrenheit.

hyperemia in the area of their innervation. This is illustrated in Figure 4 where spinal anesthesia gave no further increase in

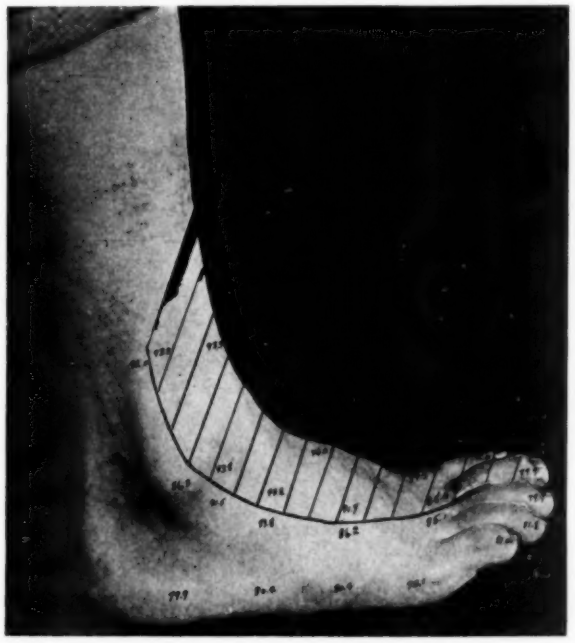

FIG. 4A. Foot in case of thrombo-angiitis obliterans. Anterior and posterior tibial nerves as well as superficial peroneal nerve have been blocked. This has resulted in relief of vasomotor spasm and hyperemia of sole and dorsum of foot. Lines mark zone of anesthesia on dorsum of foot.

temperature in the foot where the anterior and posterior tibial, as well as the superficial peroneal nerves were already blocked.

CASE XXIX. I have recently taken advantage of this observation in a man with extremely cold ulcerated feet following a fracture of his twelfth dorsal vertebra with spastic paraplegia. A spinal fusion made lumbar puncture impossible. Injection of his sciatic nerve showed that paralysing the vasomotor fibers to the foot caused an increase in temperature in the toes from 68.8° (7° below room temperature) to 95.5°.*

COMMENT

Table 1 gives a summary of all the cases in which novocaine has been used to block the cerebrospinal or sympathetic pathways to determine the effects of operation. In only one instance have I been unable to block the desired nerves. There have been no complications. The patients themselves have minded the test very little; in fact two volunteered the informa-

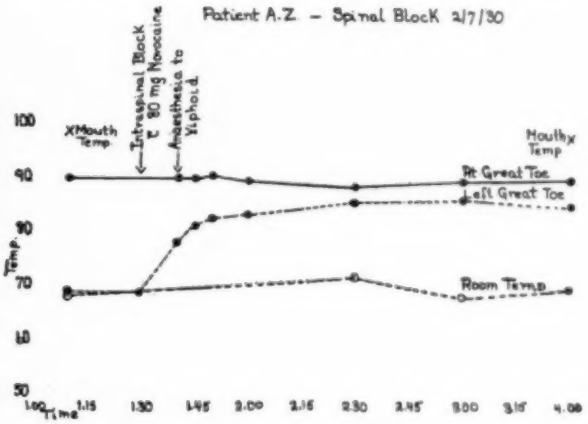

FIG. 4B. Effect of spinal anesthesia. No further rise of temperature in foot where peripheral nerves are blocked. Marked rise in uninjected side. This shows that peripheral injection is as good a method as spinal anesthesia for testing the effect of ganglionectomy on circulation.

tion that paravertebral injection of the upper dorsal sympathetic rami was much less disagreeable than the intravenous foreign protein test for vasomotor spasm. Novocaine infiltration of the sympathetic rami and ganglia has a further advantage over the intravenous foreign protein test; it duplicates exactly the effects of operation, whereas the latter gives little help in the matter of pain and is at best only a qualitative test for the effect of operation on circulation. In fact in our hands it has sometimes been definitely misleading. (CASE XXIX.)

The only difficulty with the nerve injection method is that novocaine is so diffusible that it may block more nerves than one expects. This is particularly true in blocking sympathetic rami. In the thoracic region the novocaine can easily diffuse downwards in the loose connective tissue between the pleura and the spine, thereby infiltrating the third and fourth rami when only the first and second have been directly injection. However, I have never seen it diffuse upward and involve the brachial plexus. The test is therefore quite accurate in differentiating pain involving the sym-

* Bilateral lumbar ganglionectomy has raised the temperature of both feet to this level.

pathetic nervous system from the more usual variety which enters the cord over the posterior roots of the brachial plexus.

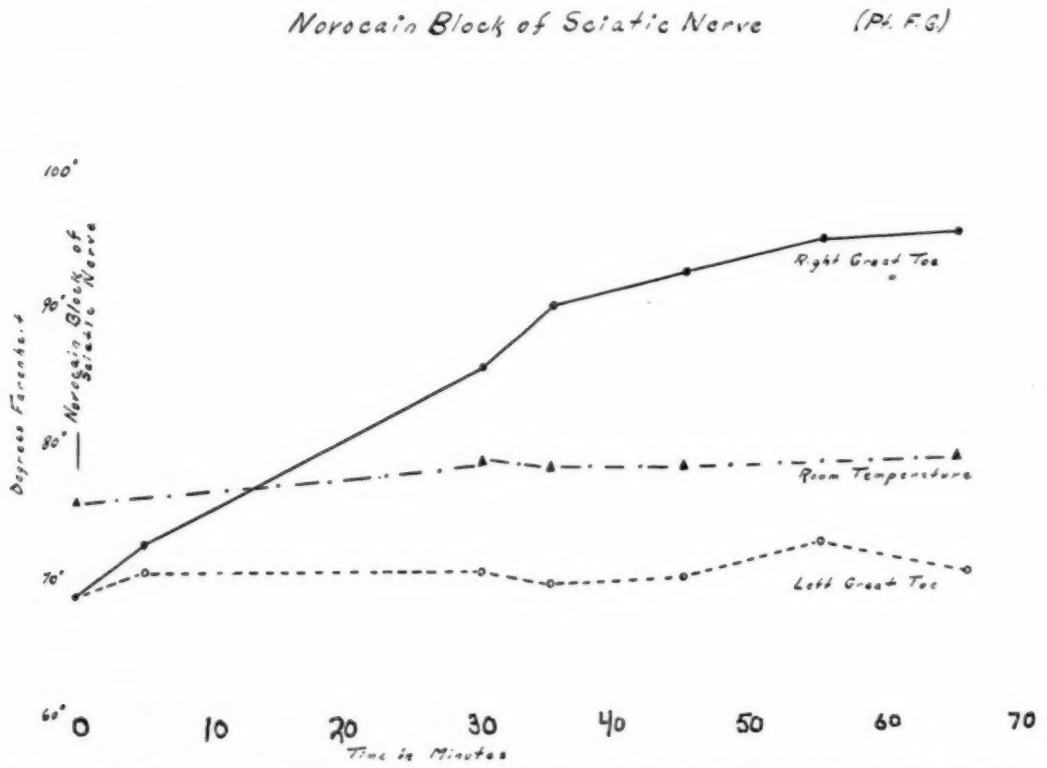

FIG. 5. Elevation in surface temperature of great toe in CASE XXIX following novocaine block of sciatic nerve.

This is a very important point, as there are numerous cases on record where all the posterior roots of the brachial plexus have been cut without relieving severe cases of causalgia or amputation stump neuralgia. In blocking the lumbar sympathetic trunk, it is also possible for the novocaine to diffuse down along the psoas muscle and produce an anesthesia of the main nerve trunks to the legs; this can spoil the selectivity of the sympathetic block. The solution of this difficulty is to use every effort to get the needle as close as possible to the desired sympathetic structures and then to use the smallest possible amount of novocaine. For selective injection of the thoracic sympathetic rami I would recommend using 2 c.c. of 2 per cent novocaine instead of the 5 c.c. of 1 per cent recommended by Labat for thoracic anesthesia. Similarly for the injection of the lumbar sympathetic ganglia, it is better to infiltrate only 10 c.c. of 2 per cent novocaine against the anterior-lateral aspect of the second lumbar vertebra than 50 c.c. of the 1 per cent solution recommended for splanchnic anesthesia. It is not necessary to infiltrate the lower lumbar ganglia to secure a sympathetic paralysis of the leg, as the lowest white

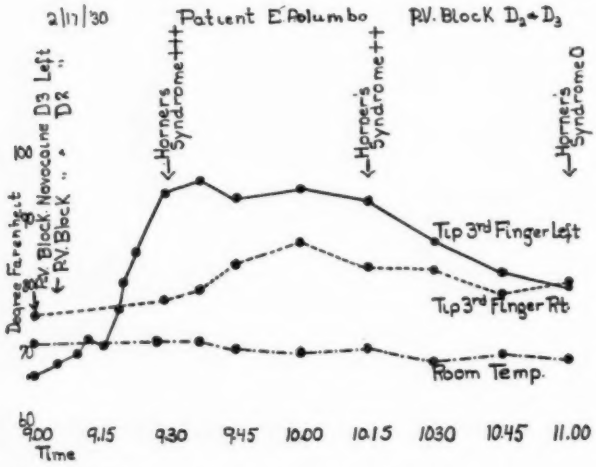

FIG. 6. Paravertebral novocaine injection of upper dorsal ganglia in CASE XXV, showing maximum rise of temperature in left arm. Delayed rise in right arm due to diffusion of novocaine across to right sympathetic trunk.

ramus communicans joins the sympathetic trunk at its second lumbar ganglion.

The rapidity of onset and the duration of the effects of novocaine are interesting. When the sympathetic ganglia are injected, the onset of the vasodilatation in cases of vasomotor spasm usually becomes noticeable in fifteen minutes and may last anywhere from one to two hours (Fig. 6). With the spinal anesthesia test, however, the leg in cases of vasomotor spasm warms up as soon as the anesthesia ascends above the umbilicus, in two to five minutes as a rule (Fig. 7a). But in patients with thrombo-angiitis obliterans the rise, if the arteries are capable of dilating at all, is much less in degree and slower in onset, often requiring three-quarters of an hour to reach its maximum (Fig. 7b). In the instances where pain is blocked, the relief when the peripheral nerve trunks are involved usually lasts as long as the regional anesthesia, but where the pain is referred over the sympathetic nervous system the pain disappears quite constantly for from twenty-four to thirty-six hours. I have no explanation for this.

I feel that there are great possibilities for this test, both for practical work in the clinic and for research in nerve physiology. It can foretell that a certain type of nerve section or posterior root section will not relieve a patient's suffering; or on the other hand, enable the surgeon to perform such a radical procedure as sympathetic ganglionectomy with a definite assurance that it will stop an unusually perplexing type of pain. It can tell the surgeon just how many nerves or ganglia he must interrupt to secure the result he wishes, also exactly how much he can increase the circulation in an extremity with any type of circulatory insufficiency. Finally, it gives the patient a thorough demonstration of what operation can accomplish and an opportunity to decide for himself whether he wishes to have it performed.

The use of novocaine in determining the pathways of visceral pain, as I have said before, is to be credited to Von Gaza; its use in predicting the effect of sympathectomy on circulation and pain in the extremities is based on work recently done on the Surgical Services of the Massachusetts General Hospital.

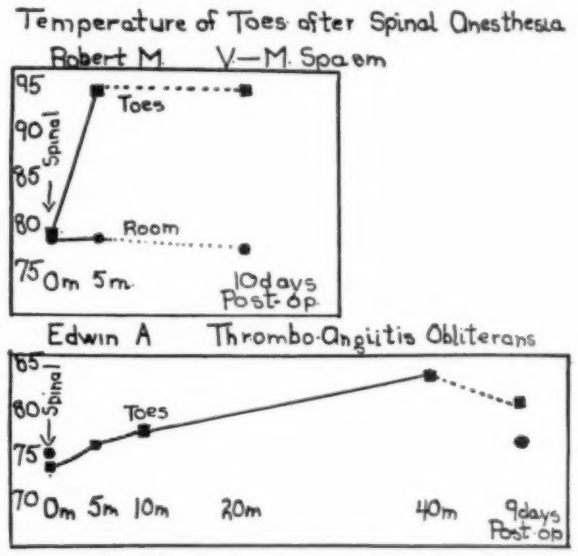

Fig. 7a. Rapid rise in temperature of legs following spinal anesthesia in patient with vasomotor spasm. Case xx.

Fig. 7b. Slow rise in temperature in patient with thromboangiitis obliterans. Case xxiii.

SUMMARY

Diagnostic novocaine block is a safe and simple procedure. We have used it to date in 29 cases with only a single confusing result.

It gives both the surgeon and the patient an exact idea of what a proposed operation on the peripheral nerves or sympathetic ganglia is capable of accomplishing.

It shows just which spinal nerves or sympathetic rami are conducting pain and how many must be interrupted to desensitize the patient.

In peripheral circulatory disease novocaine block of the regional vasomotor nerves shows in a quantitative fashion how much circulation can be improved by ganglionectomy.

The test has proved to be of the greatest value in planning new ways of relieving pain in angina pectoris, aneurysm, tabes dorsalis, causalgia, amputation stump

neuralgias, and other conditions of unknown cause.

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DISCUSSION

Dr. Byron Stookey: Dr. White has presented a very valuable method in determining just what neurosurgical procedure shall be done, and what the results of this neurosurgical procedure will be. The use of typhoid vaccine as he has very rightly said, as a matter of purely a qualitative thing, and novocaine, has permitted him to determine with precision just what the temperature of that extremity would be after the ganglion has been removed or when the section has been performed.

That contribution, had he come to us to present that and that alone, would have been, in my opinion, a tremendous contribution, one well worth listening to, and sufficient in itself. But in addition to that he has also shown that there are other procedures which may be used which heretofore so far as I am aware have not been employed, namely, the injection of novocaine in the subarachnoid space to prove that this also will give a sympathetic block which, of course, it does. He has merely applied a well-known anatomical fact to a definite clinical problem, presented it, and after he has presented it, all of us who have heard it have said, why have we not done that before? Which is always the fact when any great truth has been presented. The facts have all been before us but we have never had enough sense to put them together. Dr. White has put them together for us. It is certainly a great value to be able to tell the patient that this operation is going to succeed, that you are able to give to him that relief which has been obtained by novocaine injection, whether it be of the ganglia or in the subarachnoid space or in the nerves.

I am extremely interested, in addition to his work demonstrating the advantages of sympathetic paralysis and in the realm of circulatory disturbances, in his presentation as to what he can do for the relief of atypical forms of pain. The case of the man who had an amputation of his distal phalanx, which he cited, is extremely interesting. Subsequently Dr. White apparently was forced to take off the second phalanx, and then afterwards he proved that the pain was a pain referable to the sympathetic system, and not to the somatic system.

I believe that the pain this man had and the other painful affections which Dr. White has relieved, are due primarily to vasorestriction and I should like to know whether Dr. White made any temperature studies of some of these atypical cases where he has relieved the pain by sympathetic section.

I am not in accord with Dr. White's viewpoint entirely as to the afferent pathway of the sensory fibers of the sympathetic. We all are certain that the sympathetic ganglion cells lie in the dorsal ganglia. They are evaginations

from the neural tube at the time when the neural tube is beginning to close, and when the formation of the ganglionic crest is beginning and the sympathetic ganglion cells lie in the dorsal ganglion, not in the sympathetic ganglia. The sympathetic ganglia is made up of effector cells, that is motor cells, and not sensory cells, to the best of our anatomical knowledge.

If Dr. White has any additional information in this regard, I shall be very much interested as a neural anatomist. But I believe that if the sympathetic ganglion cells lie in the dorsal spinal ganglia, and you remove the sympathetic ganglia, you are removing the motor cells. It would be comparable, so far as its effect is concerned on the cells themselves, of cutting out the ventral horns of the spinal cord, rather than the dorsal spinal ganglia, for these are essentially extruded ventral horn cells.

But what you do in removing the sympathetic ganglion is not only removing these cells, but you remove the sympathetic afferent fibers that pass through the ganglia. In other words, you are cutting, I believe, the fibers from the afferent ganglion sympathetic cells that lie in the spinal cord and, therefore, of course, affect a loss of pain. But you have not removed, I believe, the cell body, nor have you gone proximal to the cell body, and between it and the spinal cord which I believe is an essential for permanent relief of pain. At least that has been our experience in other forms, and I do not see why this should differ.

Therefore, he might rightly pose the question to me of how then have I relieved the pain? "I have presented abundant evidence," he might say, "of having relieved these patients of pain," with which I entirely agree. I merely perhaps disagree with him as to how he has accomplished it. I think he has accomplished it because he has destroyed the effector side of the cell, relieved vasomotor spasm and has produced a vasodilatation, and thereby has relieved the patient of the pain which is due to an interference with the circulation.

Dr. Gaston Labat: It is very gratifying to note the progress which nerve-blocking has made in recent years. From the elementary principles of local anesthesia have evolved the elaborate procedures of regional anesthesia. New fields have just been opened whose exploration is made possible by increased application of physiological principles to the practice of nerve-blocking. Greater knowledge of anatomy and thorough familiarity with the injection technic have widened the avenues leading to success.

During the last ten years we have been actively engaged in improving the technic of regional anesthesia, including subarachnoid block, using these procedures more for surgical purposes than as a means of diagnosis or treatment.

In January 1929, our interest was aroused by Dr. Woodbridge's inquiry relative to alcohol blocking of the sacral nerves by caudal or trans-sacral injection. My pevious experience with neocaine and alcohol block dates as far back as 1917, at which time I attempted to relieve the pain of angina pectoris by the injection of 80 per cent alcohol. Neocaine injection of the splanchnic nerves for the relief of gastric crises was also performed by us nine years ago at the Mayo Clinic. The results were not very encouraging.

Since 1917, we have repeatedly used neocaine in solutions of ½, 1 and 2 per cent in the treatment of sciatica, injections being made in the sacral canal. For the last three years, we have added alcohol to the 1 per cent solution, occasionally to the 2 per cent solution of neocaine with varying results, the percentage of alcohol varying from 5 to 25 per cent. Motor function has invariably been affected immediately after the injection of a 1 or 2 per cent solution, necessitating hospitalization of the patient for twenty-four hours. Some of the injections were made in the patient's home.

The occasional influence of sacral block by the caudal route on the innervation of the sphincters, particularly the anal sphincter, was too disagreeable to justify the continuance of such a procedure. The fact that motor function was interfered with in both lower extremities has also had a stimulating effect on our search for a better procedure.

In this discussion, it is impossible to do more than mention the fact that in a great percentage of cases, after a correct diagnosis, injection of the first sacral nerve by the trans-sacral route has been sufficient to miraculously transform an apparently very sick patient into one with a smile of relief.

The quantity of solution injected varied between 4 and 6 c.c., the concentration of alcohol between 10 and 50 per cent. The relief in every case has been instantaneous and perfect after a single injection, so that we would be justified in calling this a better procedure than the caudal injection which necessitates large

amounts of fluid and interferes with a wider nerve distribution. In 1 case, however, the injection of the first sacral left a certain area in which pain disappeared by the injection into the sacral canal of 25 c.c. of a 2 per cent solution of neocaine without alcohol, the patient being instantly relieved.

Many patients suffering from neuralgic pain of obscure origin and from chronic arthritic conditions find no relief in the most varied treatments applied by the family physician. As a last resort, the use of morphine transforms these patients into drug addicts.

For the last year, Dr. M. Greene of Brooklyn and myself have been studying the application of nerve-blocking to these cases. Up to now we have had 21 cases under observation; a great percentage are patients suffering from pain in territories supplied by the external cutaneous and anterior crural nerves, sometimes the obturator nerve as well. Tenderness, as revealed by the electric percussion hammer, was sometimes along the path of these nerves, but occasionally along obscure lines rendering accurate diagnosis rather difficult. X-rays invariably showed productive osteoarthritis of the dorsolumbar and lumbosacral vertebrae. Many of these cases come under the general formula: blocking the second and third lumbar nerves with neocaine and alcohol. In some of the cases, tenderness along the distribution of the sciatic nerve called for the blocking of the first sacral nerve as well. All these injections were made with a 50 per cent concentration of 95 per cent alcohol.

There were 3 cases in which the upper extremity was involved; in 2 of them the brachial plexus was blocked over the clavicle with 25 c.c. and 15 c.c. respectively of 2 per cent neocaine solution with alcohol in a concentration of 33 per cent. Motor function in both cases was greatly diminished, almost abolished for a few hours following the injection, but was completely restored the following day, the pain complained of having disappeared entirely. In 1 case of pain in the upper extremity, the blocking of the branches of the brachial plexus was thought advisable. It was performed in two sessions; the ulnar nerve was blocked at the elbow and median nerve at the wrist on the first day. A few days later the musculospiral nerve was blocked at the bend of the elbow. Alcohol was used with neocaine in a concentration of 33 per cent. The results have been perfect so far.

Three cases of trans-sacral block with 50 per cent alcohol are still under observation. They refer to carcinoma of the rectum, uterus and vulva following the application of radium emanation seeds. Blocking in the case of the vulva does not seem to have had the results which were obtained in the other 2 cases. It is impossible to predict how long will be the relief of pain in the cancer cases, but it may be possible to subsequently block other nerves.

Dr. Sterne: I would like to ask Dr. Woodbridge whether in a case of angina, where he blocked the first or sixth thoracic ganglia, whether the patient had a horny syndrome, and whether the patient complained of a sweating on the opposite side of the chest.

I have had some experience in blocking the thoracic ganglia in a case of cancer of the chest wall, involving the head of one rib. The patient had been on morphine, about 8 grains per day, without relief, was bedridden, and gradually going downhill. The minute his ganglion was blocked, he was able to eat and he was able to get out of bed, and it lasted almost a year, until the disease killed him.

The other case that I had of cancer was one in which the entire abdomen was filled with carcinoma, arising probably from the ovary. I blocked the lower thoracic and all the lumbar nerve roots on both sides, with some relief of pain, but the patient only lasted two weeks. During that time she was definitely relieved of most of the pain, but she still had some pain which required medication.

I have had recently 2 cases of thromoangiitis which I have blocked by injecting the twelfth, first and second lumbar nerve roots on the same side, with definite satisfactory results. That procedure involves not only the sympathetic fibers, but also some somatic nerves which send fibers to the blood vessels of the lower extremity. The first patient that I treated is now five weeks old, and his foot has remained warm ever since the procedure. The second is two weeks old and his foot likewise is warm.

These men's feet were absolutely cold for several years, and they were on the verge of committing suicide because both had had previous amputations of the opposite limb. The application of block to old myelitis cases is very important because I think we will be able to do a lot towards improving the circulation of the limbs of these children who are so unfortunate.

Dr. Philip D. Woodbridge: In regard to Dr. Sterne's question about Horner's syndrome: The patient unfortunately lived quite a distance away and so went out of my direct observation. I am therefore unable to answer the question.

Dr. White: Just a word about the subject Dr. Stookey brought up concerning these patients who have causalgias and major amputation stump neuralgias. I saw three or four in Strasbourg with Dr. Leriche. They had occurred following shrapnel wounds of the hands or puncture wounds over a major artery, in 1 case following a chronic sepsis just above the wrist. In most of them a primary low amputation had been done, then one or more neuromas had been exised, and when that failed to give permanent relief, the nerves had been interrupted higher up. All these measures failing, one or more re-amputations had been done, each amputation stump successively becoming painful. One man had five amputation stumps and ended up with a painful shoulder.

Leriche had started out by doing posterior root sections, and he failed three out of four times to relieve them of their pain, although he was sure he cut every posterior root from the fifth cervical to the first dorsal. W. J. Mixter in Boston had had an exactly similar experience in 2 or 3 cases. Leriche had carried it one stage further and, when he failed by posterior root section, he had removed the stellate ganglion through the neck and that had, so far as I know, always succeeded. I saw 2 of the cases and it had succeeded very well. It is very difficult for me to say just what happens here; why in a case of that type we do not get relief when we cut all the somatic fibers we know of coming from the extremity and why we should then get relief by removing the sympathetic ganglia. You see that this happened in the patient whom I spoke about with the tabetic crises. He had had his posterior roots out from the seventh dorsal to the eleventh dorsal. Theoretically, all the innervation of the stomach and abdominal wall had been interrupted, yet he continued to have pain. He did not have a cold abdominal wall. I do not see how we can work vasomotor spasm into his case. Yet, posterior root section had not given relief while the removal of the sympathetic pathways to the stomach did give relief.

That gave us the choice of one or two possibilities, it seems to me. Either some of this pain can come over anterior roots, or the sympathetic innervation from the viscera and the arteries covers a great many more segments than the corresponding somatic innervation.

Langley has shown that in the arm the vasomotor fibers do not come off the roots that correspond with the brachial plexus, but that they leave the cord from the fifth to the ninth dorsal segments; they then rise in the sympathetic dorsal trunk until they get to the first and second ganglia and their grey rami come off and go to the trunks of the brachial plexus. If the sympathetic motor fibers follow that course, it is possible that the sensory fibers follow a similar route.

I do not want to imply that these pain fibers are necessarily sympathetic nerves. Ranson has shown that they are medullated, that they have their cells of origin in the posterior root ganglion. They run through the sympathetic ganglia without any synapses directly to the viscera. It is perfectly possible that they are cerebrospinal pathways. But from the point of view of the surgeon the point of greatest importance is that they run in the sympathetic trunks.

That is the most satisfactory explanation I can give, but I think you will have to admit that in some of these cases as in the aneurysm and in the tabetic crises, it is pretty difficult to account for the pain as due to any motor effect. And if the pain were due to a motor effect, how could it get back to the sensorium if the posterior roots had been cut, unless it came over some unusual course?

In all the cases of hand pain it was very obvious that the hand was cold. In these it might be justifiable to say that the vasospastic element had something to do with the pain. The peripheral skin temperatures in all those cases were very close to the temperature of the room, whereas the temperature of the normal hand in a room of 70° F. is usually about 85° F.

I was very much interested in Dr. Sterne's description of that patient with thromboangiitis obliterans. We have been trying to find out what communicant rami carry the vasomotor fibers to the legs. I would like to know if he took the skin temperatures in that case and how much they were increased?

Dr. Sterne: We did not take any accurate measurements, but the difference was so perceptible it was noticed by the patient. Both patients the evening that the injections were done said that their feet were so warm that they had to throw the blankets off.

THERAPEUTIC NERVE-BLOCK WITH PROCAINE AND ALCOHOL*

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THE earliest form of alcoholic injection of peripheral nerves for therapeutic purposes is the one that is most commonly used and generally accepted today: that for the relief of trigeminal neuralgia. Since Schlösser's original publications,[79–81] the fundamental principles involved have been applied with varying success to a variety of ailments in diverse regions of the body. It is my purpose in this paper to assemble brief résumes of the more important work that has been reported from time to time in this field, and to present a few cases that have come under my care, selected to illustrate the favorable results that may be obtained.

PARAVERTEBRAL AND OTHER PERIPHERAL NERVE INJECTIONS

For Pain in the Head and Neck: The pain of carcinoma of the face and neck may be relieved in a large portion of cases by alcoholic injections of the fifth nerve and of the cervical plexus. Both Fay[19] and Grant,[25,26] however, prefer rather major operative procedures on the nerves, such as intracranial neurectomy and cervical laminectomy with crushing of the posterior roots, as being more positive in their results. Grant found, however, that most patients prefer the alcoholic injections; indeed their choice seems somewhat justified in his reported results, for of 34 patients treated by injection none died and 62 per cent were relieved or improved, whereas in 10 who had operations, 70 per cent were relieved or improved, but 20 per cent died of operative complications. It would seem well to reserve operation for those cases in which repeated alcoholic injections have failed.

The pain of carcinoma of the tongue, tonsil and base of the skull has also been successfully relieved by alcoholic injection of the branches of the fifth nerve.[30] With invasion of the nasal sinuses, relief is less sure,[26] and pain referred to the external auditory canal and the center of the pinna has baffled attempts at relief because of its involved and deeply-seated nerve supply.[19,26]

Attempts have been made to relieve spasmodic twitching of the facial muscles by alcoholic block of the seventh nerve, but the likelihood of causing paresis or temporary pasisraly makes this procedure of doubtful merit.[23,30,81] It would seem better to direct treatment toward the fifth nerve in most cases, as the twitching is usually a reflex response to stimuli transmitted by this nerve. In contrast to the usual injection treatment of trigeminal neuralgia, Sluder and Ruskin[78] have advised alcoholic injection of the sphenopalatine ganglion in cases in which both the fifth and the seventh nerves are involved, since both communicate with this ganglion.

CASE REPORT

CASE 1. *Carcinoma of neck; alcoholic injection of cervical plexus and mandibular nerve; relief.* Male, aged sixty-three, came to the Clinic on July 31, 1929, with inoperable carcinoma of the epiglottis and of the right side of the larynx and pharynx, extending widely into the right side of the neck. Externally, the largest mass, about 6 cm. in diameter, lay just below the mastoid process. Other smaller subcutaneous nodules were scattered over this side of the neck. He complained of excruciating pain extending from in front of the right ear to the vertex, coming on one to three times daily and requiring morphine for relief. The pain was attributed to deep involvement of the

* From the Lahey Clinic. Read before the Sixth Annual Meeting of the American Society of Regional Anesthesia, New York City, April 1, 1930.

mandibular nerve. In addition there was pain, though less severe, referred to the right posterior quadrant of the neck, making it very difficult for him to find a comfortable position for sleep.

On August 3 the right cervical plexus was blocked first with procaine, then with alcohol. On account of the large carcinomatous mass below the mastoid process, the posterior approach had to be used in place of the preferred lateral route. Four c.c. of 2 per cent solution of procaine hydrochloride was injected at the tip of the transverse process of each of the second, third and fourth cervical vertebrae, followed by 4 c.c. of 80 per cent alcohol. The third branch of the fifth nerve was then approached through the mandibular notch and blocked at the foramen ovale with 2 c.c. of 2 per cent procaine followed by 3 c.c. of 80 per cent alcohol.

Two days after injection, sensation to pin-prick was diminished at only a few scattered points. On August 15, twelve days after treatment, although he complained of numbness over the right side of the head and of residual pain referred to the external auditory canal, yet he seemed very considerably relieved. There had been no return of the excruciating temporal pain, and the abolition of pain from the neck had given him the greatest comfort at night that he had had for weeks. Sensation to gentle wiping with cotton was unchanged, but sensation to pin-prick was definitely diminished over the areas supplied by the injected nerves. Relief from the more severe degrees of pain continued until his death five weeks later. Post-mortem examination showed epidermoid carcinoma of the pharynx and epiglottis, with invasion of the wall of the larynx, and with metastasis to the cervical and bronchial lymph nodes, the pleura, lungs and diaphragm.

In tuberculous laryngitis, the extremely distressing dysphagia, likely to lead either to partial starvation or to dependence on the cocaine spray, may be relieved by injection of the superior laryngeal nerves with 2 c.c. of 60 to 75 per cent alcohol,* or of its internal branch with 0.5 to 2 c.c. of alcohol.[20,36,53] In either case, the solution should contain a small amount of cocaine or procaine. Fetterolf, Lukens and Swetlow each report less than 10 per cent of failures with the method. Some patients experience increased pain for a few days following the injection and weakness of the pharyngeal muscles; occasionally this latter persists for some weeks. To avoid this complication, Fetterolf advises an interval of three days between the injections of the two sides.

In Heart Disease: A field with the greatest promise of a brilliant future is the treatment of cardiac pain by injection methods. As a consequence of Wenkebach's discussion of the dangers of existing operations for angina pectoris at a meeting of the German Society of Internal Medicine in 1924,[6] Brunn and Mandl tried paravertebral nerve-block with procaine, and reported some strikingly good and lasting results.[8,54–56] The use of alcohol instead of procaine, predicted by Brunn in 1926,[7] was first reported by Swetlow of New York City after his successful use of this procedure in 8 cases.[87–90] Since then others have written favorably of the method* and the Whites and Richardson of Boston have been investigating it from both the laboratory and clinical points of view.[72,97,98] It is preferred to the numerous operative procedures that have been devised, because these frequently fail, being based on insufficient knowledge of the pain pathways, and because they present a very high mortality. With alcoholic block, on the other hand, no serious complications have been encountered and there has been no operative mortality. Furthermore, relief has been more constant, presumably because the point of attack, the rami communicantes, is the probable final common pathway of pain impulses to the cord regardless of their route up to this point. In selecting cases for this treatment, some prefer to limit themselves to those in which the distress is most severe and the disability greatest; they fear possible serious complications from placing alcohol so near to the pleura and the spinal cord.[72,98] Before making the injection, Swetlow

* See Ref. 50, 51, 86, 88, 89.

* See Ref. 13, 44, 71, 82.

maps out the zones of hyperesthesia and hyperalgesia and plans injection to anesthetize these zones, on the ground that the second to fifth ribs and spread to the left shoulder and arm. Electrocardiographic examination confirmed the diagnosis of angina.

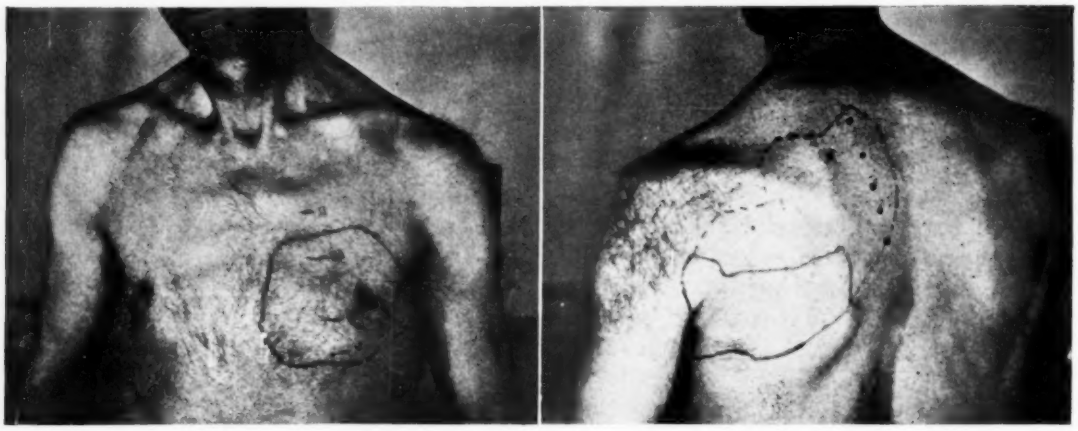

FIG. 1A. FIG. 1B.

FIG. 1. CASE II. Paravertebral alcoholic block for angina pectoris. Areas of complete and partial anesthesia are outlined. Upper border probably determined by overlapping of cervical nerves (not injected). Roman numerals indicate ribs. Dots indicate approximate points of injection.

nerve roots and dorsal root ganglia that supply them are presumably the ones kept in a state of irritation by bombardment of afferent impulses from the heart.[90] White, on the other hand, anesthetizes the upper five thoracic nerves as a routine.[97] Each nerve is injected with 5 c.c. of 1 per cent solution of procaine, followed by 5 c.c. of 85 per cent alcohol. Relief of pain follows promptly and persists for several months; other symptoms such as dyspnea are, of course, not influenced. Usually there is troublesome hyperesthesia for about six weeks following injection, which, however, is not as severe as that which follows sympathectomy. Horner's syndrome also is usually present (contraction of the pupil and narrowing of the palpebral fissure on the injected side).

CASE II. *Angina pectoris; paravertebral alcoholic block; relief.* Male, aged fifty-three years. Occupation: helper on moving van. When first seen, in May, 1929, he gave a history of precordial pain of one year's duration. This had gradually increased, so that he was then having attacks of severe anginal pain three to four times a week. It usually lasted from one to four hours, required morphine for relief, and had forced him to give up his work. The pain started in the left nipple line from the There was increased sensitivity to pin-prick over the left chest anteriorly from the second to the fifth rib. On May 25 paravertebral block of the left first to sixth thoracic nerves was done, with 7 c.c. of 1 per cent solution of procaine hydrochloride on each followed by 6 c.c. of 80 per cent alcohol. Anesthesia was produced from the lower border of the second rib to the lower border of the fifth rib (Fig. 1). A report from his home physician four months later stated that troublesome hyperesthesia had been present for seven or eight weeks after the injection, but that there had been complete absence of attacks of pain referred to the precordium and left arm. Disability, however, had continued, because of moderate, steady pain in the chest, severe pain in the abdomen and nausea, all of undetermined etiology.

In Disease of the Lungs and Pleura: Relief may also be given in other intrathoracic diseases whenever suitable indications are present. Subcutaneous local anesthesia with 0.5 per cent procaine solution has been induced with success in a few cases of pleurisy and acute pericarditis.[73,74] The pain returns, but in less severe form, when the immediate effect of the procaine wears off. After the paravertebral injection of procaine, relief lasting for one day has been obtained in carcinoma of the pleura and in pneumo-

thorax.[24] In contrast to these evanescent results, lasting effect has been realized by Swetlow by alcoholic paravertebral block in 5 cases of tuberculous pleurisy.*[,88,89]

In Disease of the Stomach: In the therapy of diseases of the stomach, the most noteworthy achievement also appears to be that of Swetlow in relieving the pain of tabetic gastric crises by paravertebral alcoholic block.[88,89] He advises its use only when pain is the sole or main symptom. Operations previously devised to relieve this symptom-complex (Foerster and Moskowicz) had resulted in a large percentage of failures and a high mortality. Others have reported success in the use of procaine, both by paravertebral and by local subcutaneous injection, in abolishing the pain of gastric ulcer and carcinoma as well as of tabetic crisis.† The sixth to eighth and sixth to tenth thoracic nerves on both sides are those most commonly injected. The conclusion seems justified that paravertebral nerve-block by either procaine or alcohol is a suitable means of treating these conditions when merely palliation is sought, alcohol being chosen when it is desired to make the effect enduring.

In Gall Bladder Disease: In abolishing gallstone colic, very definite success has been reported by several writers by the use of procaine either paravertebrally‡ or subcutaneously.[47,73,74] In treating 27 patients who had repeated attacks of gallstone colic, Mandl found that in 22 of them, paravertebral procaine injection was followed by freedom of pain for from four months to two years; others[24] found that benefit lasted for a few days only. Injection is to be made in the vicinity of the right tenth or ninth and tenth thoracic nerves. If relief does not follow the blocking of these nerves, it is evidence that the disease has spread beyond the limits of the biliary tract.[24,42,43] The injection has been found to be of considerable value in the control of postoperative pain, especially when this brings about inhibition of the cough reflex and thereby endangers the patient's condition.[42,43] Aside from this use, its field would appear to be limited to tiding patients over until operation, relieving patients when operation is contraindicated, and serving as an aid in differential diagnosis. The reports of lasting relief from the injection suggest the possibility that it may aid the passage of calculi by eliminating reflex spasm and permitting normal peristalsis.

In Renal Disease: In cases of renal or ureteral stone and of reflex oliguria, noteworthy effects have been produced by the induction of regional anesthesia. Renal colic recurring in a succession of attacks has been relieved for periods of six to fourteen months, and functional anuria, such as that following prostatectomy, has given way to polyuria, after procaine block of the twelfth thoracic and first lumbar nerves.* Studies of its action in both the laboratory and the clinic have indicated that, when these nerves are blocked, the blood supply to the kidney and the amount of excreted urine are both increased, the amount of dissolved substance in the urine is increased (always absolutely increased, occasionally even relatively), ureteral spasm is abolished, and peristaltic waves are increased in frequency and vigor.† These various factors would obviously aid either nature or the cystoscopist in the expulsion or removal of a stone, and would occasionally have a salutary effect when urinary excretion was seriously diminished without corresponding structural damage to renal tissue.

Case III. *Undiagnosed pain of right flank; paravertebral alcoholic injection; relief.* A male patient, aged forty-seven, came to the Clinic in December, 1928, complaining of pain in the right arm and shoulder. Later this gave place to increasingly severe pain in the thoracolumbar region of the back and flanks. Careful general examination as well as neurological, orthopedic, gastroenterological, cardiac and

* He also reports treating 2 cases of malignant disease of the pleura, but does not state the results.

† See Ref. 40, 42, 43, 47, 54, 74.

‡ See Ref. 8, 24, 42, 43, 54.

* See Ref. 8, 39, 42, 43, 54, 73.

† See Ref. 39, 52, 63, 100.

pulmonary examinations failed to reveal any adequate cause, and various forms of treatment failed to bring relief. In July, 1929, the relentlessly severe pain made symptomatic relief by alcoholic injection appear advisable. At that time the worst pain was in the back and flanks from about the eighth to the twelfth thoracic segments, and was slightly more severe on the right than on the left. The patient appeared worn and haggard; he had had no sleep for many days, and salicylates and codeine had given no relief.

Since no satisfactory diagnosis had been made, the prospect of abolishing the pain by alcoholic injection seemed very doubtful. It was decided to treat one limited area first. Accordingly, on July 25, paravertebral block of the right seventh to twelfth thoracic and first lumbar nerves was done with 1 per cent procaine followed by 80 per cent alcohol. That night he slept well for the first time in many weeks. The following day he continued to make up lost sleep. There was dulling of sensation to pin-prick over the area supplied by the treated nerves, but his relief seemed out of proportion to the extent of the area anesthetized. On July 27 an embolus lodged in the left femoral artery; embolectomy was unsuccessful and amputation at the mid-thigh was done on August 6. Malignant endocarditis was suspected, but physical examination revealed no sign of it. Twenty-four days after injection he died suddenly, having had no recurrence of the pain in the back and flank. A limited autopsy showed malignant endocarditis, extensive metastatic carcinoma of the liver and lungs, primary in the bile ducts, and pulmonary embolus as the cause of death. The pain of which he was relieved by alcoholic injection was presumably due to an infarct of the kidney or to pressure on the spinal nerves or cord from metastatic carcinoma.

For Pain in the Pelvis and Lower Extremities: In the treatment of sciatica, the high acclaim that has been accorded a large number of drugs[9,31] and methods, and the failure of any of these to be adopted by the profession generally, make one suspect that some of the reports may have been written in a spirit of over-enthusiasm. Schlösser, who, in his work with trigeminal neuralgia, originated alcoholic injection of peripheral nerves, recommended the method in sciatica after using it in 38 cases.[81] Most of his followers, however, abandoned the method because they found that in both their clinical and laboratory work it was frequently followed by paralyses.* The perineural injections of 10 c.c. of 30 per cent to 50 per cent antipyrin solution on the one hand[32,34,35] and of large amounts of phyisological saline solution on the other,[9,31] appear to be worthy of further clinical use. Both preparations have been used with apparent success in many hundreds of cases by their proponents.

The epidural injection of various solutions into the sacral canal through the sacral hiatus has been used very extensively not only for sciatica but for a large number of other conditions as well, such as lumbago, coccydynia, painful amputation stump, lightning pains of tabes, functional urinary incontinence and undiagnosed pains of the pelvis and lower extremities. The French have tended to favor the use of "serum artificiel,"† and have given most extravagant reports of cures in several thousand cases of most diverse nature.‡ Good results have been more conservatively reported from the use of antipyrin and of quinine urea hydrochloride.[33,37] Feuillade writes convincingly and very favorably of his results in treating soldiers with sciatica due purely to exposure, by injections of "serum artificiel," cocaine or stovaine, repeated up to eight times at intervals of three to four days. Rosenheck and Finkelstein, using procaine solution and physiological saline solu ion,[75] found their results very inferior to those of Feuillade, and attributed their relative failure to the fact that most of their cases were secondary to orthopedic conditions rather than of the so-called idiopathic type.[76,77] In this country and in Canada the repeated epidural injections of procaine have been more favorably received than the other methods previously mentioned.[58,93,94] By this means and by

* See Ref. 5, 15, 22, 23, 30, 61.
† Physiological saline solution.
‡ See Ref. 11, 12, 21, 29, 83.

the removal of foci of infection, Ott of the Mayo Clinic treated a group of patients whose sciatica was not secondary to other disease; he restored to their work or permanently cured 66 per cent of them.[67,68] Before treatment 79 per cent of the group were either bedridden or required a crutch or cane. The method continues to be in such favor there that it is still used regularly as an accepted form of treatment.[14]

Case IV. *Painful carcinoma of urethra and bladder; alcoholic sacral block; relief.* Male, aged forty-two, came to the Clinic late in June, 1927, complaining of melena, rectal pain and tenesmus. In July a colostomy was made and the rectum excised for adenocarcinoma of Grade 3 malignancy. In December, 1928, carcinoma of the prostatic urethra was found. Suprapubic cystostomy and *x*-ray therapy failed to give relief. For months his sleep was interrupted every few minutes by urethral burning and a feeling of urgency. Intense pain was referred to the penis and perineum, especially in the former location of the anus. He repeatedly threatened suicide and begged piteously for anything that might lessen his suffering. It was therefore decided to run the risks incident to blocking the sacral nerves with alcohol. The patient was willing to face the possibility of paresis or paralysis of the lower extremities; the sphincters needed no consideration on account of the colostomy and cystostomy. A preliminary trial sacral anesthesia with procaine gave complete relief for six hours, and freedom from urethral pain for twenty-four hours. With this promise of success, alcoholic block was undertaken a few days later, on January 4, 1929. It was hoped that caudal injection might be omitted and trans-sacral injection used alone, in order to prevent upward diffusion of the alcohol. This procedure, however, could not be followed, as the patient would not tolerate the insertion of needles into the foramina until some degree of analgesia had been produced. Therefore the sacral canal was first injected with 20 c.c. of 1 per cent procaine solution, and each of the second, third, fourth and fifth foramina with 5, 3, 2, and 2 c.c. respectively. In order to minimize its upward diffusion, only 8 c.c. of 80 per cent alcohol was injected into the sacral canal, and that very slowly, the point of the needle being withdrawn meanwhile from the level of the second pair of foramina to that of the fifth. For the second, third, fourth and fifth pairs of foramina, 8, 5, 4, and 3 c.c. were used respectively. Although a half hour had been allowed to elapse between the injections of procaine and of alcohol, there was moderately severe pain referred to the testicles with the alcoholic injection of the second sacral nerves and to the bladder with the third pair. The total amounts used were 44 c.c. of 1 per cent procaine solution and 48 c.c. of 80 per cent alcohol. Anesthesia of the perineum, scrotum and most of the penis persisted for at least nine months. Immediately after injection there was paralysis of the flexors of the right knee and of all of the muscles of the right foot. Half an hour later, power was beginning to return to the knee flexors. Six hours after injection both extremities, including the feet, moved freely but without strength. The following day there was fair strength in both extremities, but no power of external rotation of the right hip. From the fifth day on, the patient walked without a cane, though the gait was waddling and weakness persisted in the abductors and external rotators of the right thigh and in the extensors of the right toes.

For several months after injection there was no return of the severe pain referred to the bladder, penis and perineum, except that on January 12 and 13 there was transient pain in the penis. However, nine months after the first injection of alcohol new areas of agonizing pain developed in the suprapubic region and below the right inguinal ligament. Paravertebral block of the right first and second lumbar nerves with procaine and alcohol resulted in complete transient relief followed by return of the pain in somewhat less severe form, although anesthesia to pin-prick persisted. This pain appears to have been due to an abscess which worked its way to the surface in the anterior aspect of the thigh, where it was later drained. The mental disintegration which occurred before death and the probable spreading of the carcinoma to unanesthetized areas made it impossible to judge whether relief from the first alcoholic block persisted after nine months.

I have found no report in the literature of a previous attempt to produce sacral block with alcohol. However, since this patient was treated, it has come to my

attention that Labat has been using this procedure with caution for a number of years, and has obtained more or less encouraging results in the treatment of various pelvic conditions and of sciatica.[41] In order to avoid paralysis of the sphincters, he suggests starting treatments with procaine dissolved in a 10 per cent solution of alcohol, and increasing the concentration of alcohol until motor function is slightly interfered with.

Diagnostic Use of Paravertebral Anesthesia: In Germany considerable use has been made of paravertebral anesthesia as an aid in differential diagnosis as well as in therapy.* Since biliary colic is relieved by blocking the right ninth and tenth thoracic nerves, renal colic by blocking the twelfth thoracic and first lumbar, gastric pain by blocking the right and left sixth to eighth thoracic, and that of appendicitis by blocking the first and second lumbar, Läwen and his followers found the method useful in distinguishing between these diseases, as well as between appendicitis and pneumonia. Moreover, the muscular relaxation which follows the injection occasionally permits the palpation of tumors otherwise undiscovered. If, as may happen in appendicitis or cholelithiasis, the disease process has spread to surrounding tissues, the paravertebral injection will not bring relief and the diagnosis will remain in doubt. Furthermore, the segmental proximity of the appendix and the kidney makes the method useless in distinguishing between diseases of these two organs. With these exceptions, the evidence afforded by the application of the method appears to have been of definite value in the hands of these authors.

SPINAL ANESTHESIA

In Ileus: Inasmuch as spinal is one specialized form of regional anesthesia, its therapeutic powers may be considered here. The value of spinal anesthesia in the relief of postoperative paralytic ileus appears to be quite generally conceded. The few adverse criticisms that have appeared have dealt mainly with its use in cases of mechanical obstruction* or of poor operative risk,[18] or have been based on an unaccepted theory of the pathological physiology involved.[92] The pioneer in this field, Wagner, handled the subject in such a masterly manner in his first reports[95,96] that other writers have not been able to add much of importance. Not only did he report and advise its use in postoperative paralytic ileus, but he also warned against its use in the presence of mechanical obstruction or far-advanced disease, and even brought out the theory of the neurological mechanism involved in recovery, which waited four years for laboratory proof.†[16,17,59] Mayer followed close on Wagner's heels, advising the use of spinal anesthesia for the release of spastic obstruction as well as in paralytic ileus.[62] Mayer's simple statement: "Naturally the method is worthless for mechanical ileus," stands out in marked contrast to the turbulent boiling of the French press four years later‡ on various phases of its use, after the subject had been introduced to that country by Asteriades.[2] After Duval had been accused of concealing the failures in his publications, he brought out an excellent and valuable analysis of 400 collected cases, and drew from them the same conclusions which Wagner had reached five years earlier. The reports which have appeared from various countries since that time indicate that the method is gaining general favor.§ The almost universally favorable nature of these reports is difficult to understand in the face of the grave risk for spinal anesthesia which a large portion of these patients present, because of their dehydration, acute malnutrition, and respiratory

* See Ref. 8, 24, 42, 43, 52, 54.

* See Ref. 18, 28, 45, 46.

† Priority of laboratory proof appears to belong to Domenech, who reported the results of his work to the Society of Biology of Barcelona on June 11, 1926. The report of Markowitz and Campbell was published one year later.

‡ See Ref. 1, 45, 46, 60, 92.

§ See Ref. 27, 38, 49, 85, 101.

embarrassment from abdominal distension. One group of recent writers in this country prefer splanchnic anesthesia as being fully as effective and considerably safer.[65,66] Attention should be drawn to the facts that if spinal anesthesia is used it may not prove effective unless it reaches to the sixth thoracic segment[16] and that with either form of anesthesia the peristalsis-inducing effect may fail to appear in case of the concomitant use of chloroform, ether, atropine,[16,17] epinephrine or ephedrine.[66] Presumably scopolamine would have a similar deleterious effect.

In Labor: In obstetrics Balard and Mahon of France have found spinal anesthesia very helpful in overcoming certain types of dystocia.[3,4] They find that it abolishes any pathological as well as the normal tone of the cervix, which then becomes flaccid and dilates with great ease and rapidity either manually or spontaneously; the contractions of the body of the uterus become more vigorous, and the perineum becomes completely relaxed. They report easy, rapid deliveries following its use in cases of contraction ring, edema of the cervix, prolapse of the uterus with cervical edema, and failure of the cervix to dilate. In difficult breech presentations, where the fetal heart has become irregular, they feel that it frequently saves the baby's life. They believe it acts by producing a physiological section of the posterior roots of the lumbar and sacral nerves. They advise its use in functional rigidity of the cervix and in the presence of any indication for the rapid termination of labor for the sake of the health of mother or child. Its effect is prompt as contrasted to that of morphine, and it does not produce the severe injuries that forcible dilatation or extensive incision produce. They have encountered no untoward results, and have found that the cervix at the time of the patient's discharge from the hospital appears the same as after normal labor.

In Eclampsia: In connection with the consideration of dystocia it is interesting to note that Paramore of England, working on the theory that eclampsia is caused by compression of the liver and kidneys, and that relaxation of the abdominal wall might relieve this pressure, induced spinal anesthesia in 1 case of fully developed eclampsia, and was rewarded with the patient's prompt recovery.[69,70]

In Tetanus: In the convulsions of tetanus, various forms of local and regional anesthesia with procaine have been used as therapeutic measures much more extensively than in eclampsia.[57,99] Spectacular relief of lockjaw follows the infiltration of the masseter, temporal and pterygoid muscles, with the result that soft and liquid food can be ingested if there is no spasm of the muscles of deglutition. The danger of precipitating general convulsions by the needle-prick may be minimized by the preliminary administration of chloral hydrate. Mandl reports 6 cases of full-fledged tetanus treated by the injection of procaine into the sacral canal, and 4 cases treated by spinal anesthesia. In every case generalized convulsions ceased for a few hours, local spasm of the muscles of the lower extremities and of the abdomen were controlled, and the patients welcomed the treatment. In some the relief was lasting and initiated convalescence.

NEUROLOGICAL MECHANISM OF THERAPEUTIC EFFECTS

If we consider the neurological mechanism involved in these therapeutic uses of regional anesthesia, there will be explained some interesting paradoxes, such as the ability of spinal anesthesia to increase intestinal activity and simultaneously paralyze the abdominal wall, and the effect of subcutaneous injections of the anterior abdominal wall in relieving pain that arises elsewhere, namely in an underlying viscus.

Paralytic intestinal ileus is conceded to be the result of reflex inhibition of intestinal peristalsis and tone; spinal anesthesia, by producing physiological section of the splanchnic nerves, breaks the reflex

arc, removes the inhibitory influence* and allows the plexus of Auerbach and the parasympathetic nerves to have free play in producing motility. Ether or chloroform anesthesia or atropine will in turn render these nerves also ineffective, and permit ileus to continue even in the presence of spinal anesthesia.

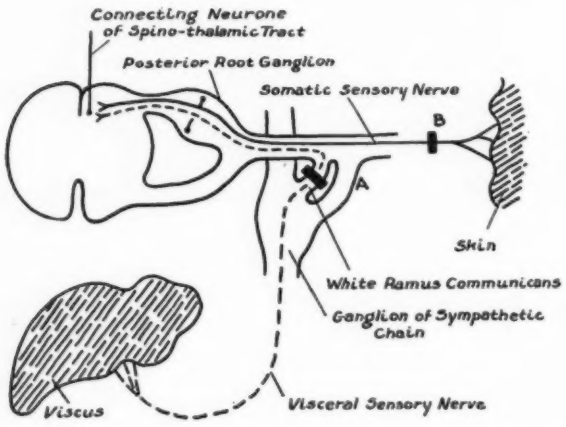

Fig. 2. Mechanism of referred pain—MacKenzie theory. Afferent impulses pass through visceral sensory neurone by way of white ramus communicans to connecting neurone of spinothalamic tract. Interpreted by higher centers as coming from somatic sensory nerve. May be interrupted by producing a block at A. This theory does not explain how a block produced at B relieves pain. (From LeMaire.)

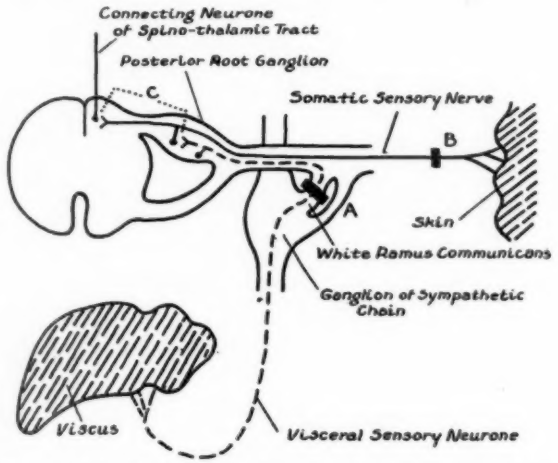

Fig. 3. Mechanism of referred pain—Edinger-LeMaire theory. Portion (C) of somatic sensory nerve interpolated in course of afferent visceral impulses. LeMaire assumes that a block produced at B affects proximal as well as distal portion of somatic sensory nerve, and thereby stops transmission of afferent visceral impulses at C. (From LeMaire.)

The therapeutic action of paravertebral anesthesia and of field block involves the mechanism of referred pain. According to MacKenzie (Fig. 2) the afferent autonomic fiber† transmits its impulse, by a synapse in the cord, to the connecting neurone which transmits it to the higher centers by way of the spinothalamic tract. This same connecting neurone has synaptic connection with cutaneous sensory nerves as well. The higher centers, being accustomed to receiving through this neurone sensory impulses which arise in the skin, interpret as coming from the skin all impulses which arrive over the same neurone; i.e., they project the stimulus not to the organ from which the impulse started, but to the skin area supplied by these cutaneous sensory nerves. This is the phenomenon of referred pain, sometimes called the viscerosensory reflex. Other authors in addition recognize the reference of stimuli to the organs themselves, a special visceral sensation, such as is perceived with extrasystoles and other forms of palpitation. Paravertebral block is believed to produce a sectioning of the ramus communicans through which the afferent autonomic fiber runs.* If done with procaine, it is a so-called physiological section; if with alcohol, it becomes an anatomical section.

This, however, does not explain the relief of visceral pain which follows local subcutaneous infiltration with procaine. In this circumstance the procaine does not directly affect either of the neurones through which MacKenzie would have the impulse pass. LeMaire, in his very interesting discussion of the problem,[47,48] therefore adheres to Edinger's theory that the visceral afferent fiber does not carry the pain impulse into the cord, there to transmit it to the connecting neurone,

* See Ref. 16, 17, 27, 59, 62, 95, 96, etc.

† Some deny the existence of afferent autonomic nerves, maintaining that all nerves which transmit sensory impulses whether somatic or visceral, are spinal nerves.

* See Ref. 8, 44, 72, 87, 90, 98, etc.

but rather that in the posterior root ganglion it transmits the impulse to the cutaneous or somatic sensory neurone, through which it is then transmitted to the connecting neurone in the cord (Fig. 3). The portion of the somatic sensory neurone that lies in the posterior root is thereby made to form one link in the transmission of the impulse from the viscus to the higher nervous centers. Therefore LeMaire has to assume that the procaine injection of the distal portion of the somatic sensory neurone must affect the function of its entire extent, thereby breaking the sensory pathway. Such a mechanism would help to explain the relief of visceral pain obtained not only by the subcutaneous injection of procaine, but also by the application of heat or cold and various forms of stupes and plasters to the skin. This theoretical functional alteration of the entire extent of the neurone seems parallel to the structural alterations found after alcoholic or other injury to a nerve trunk. Such injury results not only in the disappearance of the distal portion of the myelin sheath and axones (Wallerian degeneration),[22,64] but also in degenerative changes ("axonal reaction") in many of the nerve cells in the posterior root ganglion.[10,61]

Since alcoholic nerve-block may occasionally bring such welcome relief from pain, especially from that of malignant disease, it is a measure that the therapist should bear in mind and be ready to call into use. Moreover, its frequent success in such neurovascular disorders as reflex anuria and angina pectoris suggest that its use may possibly be extended to include the treatment of such diseases as intermittent claudication, erythromelalgia and Raynaud's disease,[91] sharing this field with sympathectomy.

DISCUSSION

Dr. Henry S. Ruth: It may be realized by consistent reasoning that any anesthetist (my antagonistic nature makes me glory in repeating that word anesthetist, because it is so belittled in some medical circles and yet some of us have so much faith in it) well, to proceed, it is logical to realize that an anesthetist, who scientifically practices regional anesthesia, as it has recently been elevated by our own President, Lundy and others, has had the necessary experience to efficiently practice alcoholic nerve-block. Any factor which will allow a further service of anesthesia will immediately and automatically raise our specialty to a higher plane.

I should like to suggest a procedure which may save some of you from an embarrassing suit for mal-practice, of which several cases are on record, although fortunately none of my own. It applies largely to alcoholic nerve-block of the fifth cranial nerve. After injection has been completed and as the needle is being withdrawn, inject just a small quantity of normal saline solution. This precludes the possibility of the alcohol which remains in the lumen of the needle from being distributed over the course of the needle as it is withdrawn and anesthetizing close-lying fibers of the seventh cranial nerve, with resulting partial facial paralysis.

Many times after repeated injections of the fifth cranial nerve, 80 per cent alcohol is not effective, whereas 95 per cent alcohol may be. To cite a case, Mr. F, seventy-eight years old, had, according to his own statement, 18 injections of the fifth cranial nerve over a period of many years, just how many he could not recall. He was referred to me and I injected 1 c.c. of 2 per cent novocaine and 2 c.c. of 80 per cent alcohol in each of the second and third branches of the fifth. No relief resulted. After a period of ten days, I injected 1 c.c. of 2 per cent novocaine and 2 c.c. of 95 per cent alcohol in both branches, after which he had complete freedom from pain and no unpleasant complications. I am certain I made an intraneural injection in both cases.

Dr. Woodbridge has not mentioned the technic of Yeomans for coccyodinia, which I have found to be useful and simple. With the index finger in the rectum, the point of maximum tenderness is determined by pressure with the thumb externally. With a small needle, puncture is made in the midline and directed immediately toward this spot; when the spot is reached, the patient usually exclaims when 10 to 20 minims of alcohol are injected.

Yeomans claims only 14 per cent failure with this procedure.

Varying results have been reported with

alcohol nerve-block of the fifth cranial associated with cervical block for inoperable carcinoma. I believe that, where the entire malignant mass is supplied by these nerve fibers, failure results from improper technic only. Strict attention to detail in this type of anesthesia cannot be over-emphasized. As to spinal anesthesia for paralytic ileus, I can add nothing, except to recommend it in the true paralytic type where the risk is not of an extreme grade.

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THE PRESENT-DAY UNCERTAINTY REGARDING TREATMENT OF UTERINE TUMORS*

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I NEVER hear the statement in medical parlance that "each case is a rule unto itself" without feeling that this teaching is a two-edged sword and in no condition to my knowledge will the double-edged sword more often take its toll than in uterine pathology.

The profession should have learned to its sorrow that the classification of the treatment of an acute lesion such as appendicitis into operative and non-operative hours, has increased the death rate in America during the past fifteen years 30 per cent, yet this is an attempt to teach that each case is "a rule unto itself," from the standpoint of surgical management.

I believe medical statesmanship is much needed in dealing with any acute or destructive lesion in which signs and symptoms are not proportionate to the severity of the lurking pathological condition.

In considering a remedy for any lesion, first we must reckon with cost, namely, mortality, morbidity, postoperative history, whether the organ can be disposed of, whether the remedy is accessible, whether it can be applied by a good number of the profession with facility and how favorable are the surroundings in which the patient is placed.

In order to simplify remedy and standardize treatment, these factors which concern mortality, morbidity, etc. then become the concern of the medical or surgical statesman whose counsel would be that a certain remedy meets most conditions. This is most true in dealing with uterine pathology.

In discussing the common lesions of the uterus we are concerned with the age of the uterus and its value to the particular patient: should the uterus be preserved even at certain risks, should conservative treatment be tried, what are the dangers of conservative treatment and what are those of radical measures. No wonder the student of the condition is afflicted with the burden of uncertainty, a precarious state of mind to deal with that which is often a rapidly fatal lesion. This is exactly the teaching which is given the student of this day and we feel it must not stand.

There is precisely such a dearth of attempts to arrive at the proper diagnosis of those conditions which may produce a bleeding uterus. Indeed, in a great number of patients who come to the hospital for a uterine hemorrhage, no attempt at diagnosis has been made.

Patients having threatened abortion or abortion, ectopic pregnancy, fibroid tumors or fibrosis of the uterus, malignancy, hyperplastic endometritis, excessive uterine hemorrhage from tubal and ovarian infection or ovarian tumors, etc., often come to the institution with the simple diagnosis of uterine hemorrhage.

All physicians have entrée to the clinical history of the patient and I am sure that a very reliable diagnosis may be made from the clinical history in over 90 per cent of the patients who are being exsanguinated from the bleeding uterus.

From what comes the lack of interest in the etiology of these preventable lesions? It cannot be ignorance. Is it the lack of habits of industry, has the examining hand been placed upon the patient, is the general profession too dependent upon the nearest consultant? We may wonder but the real crime is the loss of time and action.

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In the evening of our thoughts we may speculate upon metaphysical propositions but the gangrenous appendix and malignant uterus must be dealt with in no speculative manner.

Never was the uterus so much on trial for its surgical pathology as at the present day.

Radium and *x*-ray have much divided the opinions of men during the present era in the treatment of uterine pathology.

The first question which comes up for discussion when dealing with the pathological uterus where malignancy or any tumor is suspected, is: what is the mortality of the remedy? This is more often the determining factor than morbidity, postoperative complications, etc.

The very high death rate of the Wertheim hysterectomy makes this procedure unpopular and scores for radium or *x*-ray.

The ordinary panhysterectomy has a higher mortality than the supervaginal removal of the uterus which is not to be thought of in dealing with the malignant uterus, so again the more conservative methods are advocated.

In over 90 per cent of the malignant uteri the cervix is the site of the growth; therefore, the abdominal route of removing the uterus suffers this embarrassment, so surgery has been penalized and radium and *x*-ray have become popular in the treatment of uterine growth.

The mortality from panhysterectomy in the large clinics for malignant and benign tumors will vary from 5 to 20 per cent, supervaginal amputations may be done with a smaller death rate but is not considered in dealing with malignant growths.

For over fifty years vaginal hysterectomy clamp method has been done in the Joseph Price Hospital for all malignant conditions of the uterus where size of growth permitted removal by vaginal route and for over thirty years in this institution all uterine tumors, size permitting, when not complicated by tubal and ovarian infection, have been removed by vaginal hysterectomy clamp method.

The mortality has ranged from one-fifth to one-third of 1 per cent, so we are permitted to say that vaginal hysterectomy clamp method has the lowest mortality and the best postoperative history of any major operation with which we have had experience.

Were it not for the clamps we would not do vaginal hysterectomy.

The uterus may be removed in 90 per cent of the cases by the clamps in from three to five minutes and it permits very much more extensive removal of tissue than can be done by the ligature method; thus its virtue in malignancy.

The percentage of operability by clamp method is double that of ligature method in dealing with either malignant or benign tumors.

The rapid time in which the operation can be done and the avoidance of infection because the procedure is an outside operation reduce all untoward symptoms and calamities to a minimum.

I have never seen a sudden death due to embolus or heart collapse as is most often seen in superpubic hysterectomy. Indeed, the rate of sudden deaths following superpubic hysterectomy due to embolus or cardiac dilatation is greater than from all causes following vaginal hysterectomy.

I have seen but one shocked patient following vaginal hysterectomy; I have never seen a postoperative bowel obstruction follow vaginal hysterectomy nor a postoperative pneumonia nor a death due to suppression of the urine.

There is no trauma to the abdominal wall in vaginal hysterectomy, and all factors which contribute to shock and trauma from traction on the parietal peritoneum are avoided.

The very low death rate from vaginal hysterectomy clamp method challenges all abdominal operators and makes many of the shortcomings of the abdominal route most conspicuous.

Those operators who have not had experience with vaginal hysterectomy clamp method are in no position to discuss

the relative merits of the operative treatment of uterine tumors compared with that from the application of *x*-ray or radium.

Any operator who removes the uterus as a panhysterectomy will have from fifteen to twenty times the mortality than will occur in vaginal hysterectomy.

The patient who weighs from 170 to 225 lb. will show a frightful mortality when operated on from above as compared with the vaginal route.

I am not attempting to denounce radium or *x*-ray treatment for malignancy in general. Irradiation in locations such as the mouth, skin and superficial areas has been a great blessing, but for permanent results with deeper malignancy the results are not consistently good and the advocates of irradiation must make frank expression of its limits of usefulness.

In regard to irradiation of the malignant cervix where the best results are said to be obtained in dealing with the malignant uterus, the histopathology of the organ must be considered. In my opinion we cannot say that malignancy of the cervix is particularly amenable to irradiation especially on account of the cellular type of the malignancy but is it not due to the length of time that cervical malignancy remains a superficial growth; and it remains a superficial growth on account of the fact that the mucous membrane of the portiovaginalis has no glands, the vaginal cervix being lines with stratified epithelium in which there are no glands penetrating the deeper stroma and thus extending the malignancy to structures beyond.

Glands are not found on this area of the cervix unless they have been carried down from above by prolonged erosion.

Lacerations of the cervix permit ingrowth of epithelial cells and thus squamous cells become displaced and are found deep in the cervical tissue and this ingrowth of malignant tissue is not as amenable to irradiation as the more superficial growth.

As operators, we know that the great cauliflower-like growth of the cervix often has not extended deeply into the cervical tissues and therefore is more susceptible to treatment than the penetrating ingrowth of malignant tissue which is less conspicuous as a malignant lesion but more deadly.

There is no point of location in the anatomy where cause and effect in their relation to malignancy are so definitely depicted as is seen in the lower third of the cervix; here we have transition of epithelial cells from columnar to squamous type, we have the most traumatized area of the body in the child-bearing patient and here are cells which were bathed by a sterile uterine alkaline medium, thrust or misplaced by injury into an infected vaginal irritating acid medium, and there are also misplaced cells incident to injury which have been cut off from their normal nutritional surroundings. These injured and misplaced cells are constantly being bathed by an irritating discharge incident to the erosion, inflammation and infection.

So all these factors are important elements in predisposing this cervical area to malignancy which is forcibly shown from the fact that over 90 per cent of malignancies of the uterus occur in this area.

It is not so much my intention to go into the histopathology of the subject of uterine growth as it is my object to advise a more definite remedy which may be put in the hands of the ordinary careful operator.

A week before the death of Joseph Price, I asked him what would be his Swan Song (meaning his last message to the profession) and he said, without a second's hesitation, "The profession must be taught to do vaginal hysterectomy clamp method for all tumors of the uterus which will permit vaginal removal; it is the solution of malignancy of the uterus and the profession must be taught to do more radical work in the peritonitic abdomen." At this hour, eighteen years after his death, were I asked the same question my answer would be the same as that of my distinguished teacher.

When one takes into consideration that

Price undoubtedly had the largest experience of any operator in America in vaginal hysterectomy and probably also with the peritonitic abdomen, his message should not remain unheard; and I would like to add that it never was more needed than at the present hour.

In summing up, my points in argument would be:

1. Vaginal hysterectomy clamp method has the lowest death rate and the best postoperative history of any operation of my experience.

2. It is accessible to all ordinarily competent operators; radium and *x*-ray are not.

3. The operation from below is safe from sudden surgical tragedies, such as are often seen in the superpubic route.

4. In the fleshy patient the operation may be done with as much ease as on the spare woman and with a death rate of one-twentieth that of panhysterectomy.

5. It is a very much more thorough operation when done with clamp than with ligatures, as all tissues within the bite of the clamp sluff away and malignant and potentially malignant tissues are thus cast off.

6. The operability of vaginal hysterectomy clamp method is over twice that of the ligature method.

7. As over 90 per cent of uterine malignancies occur in the cervical end of the uterus, the vaginal route is the more accessible and malignant tissue is not drawn up into the abdominal cavity as is the case in the abdominal route.

It has been stated by Wertheim, the father of the most complete abdominal operation for the malignant uterus, that if the abdominal glands are truly malignant the malignancy will return in all probability, so the vaginal route suffers little from the standpoint of not removing the abdominal glands.

The very low mortality of vaginal hysterectomy clamp method and its almost total absence of postoperative complication place it as more than a worthy competitor with either *x*-ray or radium: indeed, I have seen a great number of complications following irradiation.

I have advised a great number of patients with simple fibroid tumors of the uterus, to have a hysterectomy performed; if they have refused operation and have been treated by irradiation, I have had these same patients return to me from four to six years after such treatment with diffuse malignancy.

Fundal malignancy is an easy victory for vaginal hysterectomy clamp method and certainly should never be considered as amenable to irradiation; too much emphasis cannot be laid here.

In fundal malignancy biopsies are most uncertain and such absence of certainty should never be met with irradiation but by removal of the organ.

In treating cervical malignancy with irradiation can we afford to take for granted the well-being of the upper two-thirds of the uterus. I am sure we must not and the removal of the uterus will save many lives.

The large percentage of cases in which the condition suggests removal of the uterus occurs in nearly all cases where the organ has finished its function and therefore may be removed without untoward results.

Any attempt to classify malignancy of the cervix into the three groups representing squamous cell, transitional cell or embryonal cell type and then applying irradiation to a particular type cell, brings forth a confusion which cannot be tolerated in dealing with malignancy.

When one compares the elements of doubt both from a pathological and a remedial standpoint which are factors in the treatment of uterine tumors with radium and *x*-ray with the element of certainty which characterizes vaginal hysterectomy clamp method, there can be little hesitation as to choice.

From a psychological standpoint the removal of the uterus for any kind of growth gives comfort of a substantial

nature, whereas the treatment with irradiation or other conservative means leaves the future full of uncertainty and apprehension.

The very low death rate following vaginal hysterectomy is a strong plea for earlier surgery, just as an acute surgical death is a deterrent for early surgery. The acute surgical death always influences a community against early surgery.

Statistics obtained from the treatment of uterine tumors by the available remedies are most unreliable, just as they are in the peritonitic abdomen. One operator would claim that a certain malignant lesion of the uterus was still operable or amenable to irradiation, while another that the same condition was past human assistance.

We are constantly seeing patients who have been refused surgical treatment on account of being too late whom we consider very good risks for vaginal hysterectomy clamp method; and we are also seeing a good number of patients who have been treated with irradiation six months or more after further like treatment had been abandoned as useless and yet we consider these patients subjects for vaginal hysterectomy clamp method; that is what I mean by saying that statistics are very unsatisfactory.

In an organ where the actual cautery can be used extensively such as in malignancy of the cervix, it becomes a worthy competitor of irradiation.

All of our malignant cases are extensively cauterized before vaginal hysterectomy is begun, the tissues being charred down to firm structures and then the entire upper third of the vagina if necessary may be removed by the clamp method. It is my opinion based upon a large experience that if the operating profession will take up vaginal hysterectomy clamp method, malignancy of the uterus can be reduced within a short number of years to almost vanishing point.

This brings out the message of my paper which is, that we have a surgical procedure in vaginal hysterectomy clamp method that has the very highest percentage of operability in malignancy with the very lowest mortality, which virtues will move all such cases toward an earlier operative hour; no several means of treatment will do this.

The technic of vaginal hysterectomy clamp method is fully illustrated in a monograph entitled Practical Surgery of the Joseph Price Hospital.

TONSILLECTOMY BY DIATHERMY

ELECTROCOAGULATION METHOD*

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MY persistence in submitting this, the fourth paper within the past four years on this subject, is due solely to the fact that I want to so impress its importance upon the profession that our internists and laryngologists will give it a thorough trial; rather this, than to have the laity force it upon the profession. I believe we are gaining ground, as I have a file filled with communications of inquiry from Boston to Seattle, and from Canada to Texas. Further, patients come from New York, Chicago, New Jersey, Philadelphia, Canada, Ohio, Illinois, West Virginia, and Tennessee, everyone of whom we believe is an enthusiastic propagandist. For these reasons I am persuaded that there is a growing interest in this subject.

What is the cause of our slowness to take up that which appears to be new? I think an editorial[1] rather apropos: The editor quotes from Walter L. Lippman's "Men of Destiny" as follows: "Although we are all endowed with eyes, few of us see very well. We see what we are accustomed to see and what we are told to see. When we find a pattern which works well, in that it allows us to feel that we have made a large area of reality our own, we are grateful, and we use that pattern until it is thread-bare." The editor comments:

> And who is better supplied with a pattern by which to shape his beliefs and his life than the physician, and who offers more determined resistance to the new discovery and the new method unless it comes well introduced by authority? Yet, who should be better equipped to realize that authority no longer holds the reins of civilization? Who should be more responsive to new ideas, for who deals with an art and a science less complete, the outermost boundaries of which have not yet been even sighted? Why, having attained his professional majority, does he so often cease to grow?

I, for one, believe this to be only too true.

We affirm that tonsillectomy by diathermy is the only new method that has been presented in tonsil surgery within the past two hundred years. In proof thereof we submit that in the latter part of the eighteenth century, Moscati, an Italian, tried scissor dissection, but criticisms from the older and more conservative surgeons kept others from giving it a trial. Earlier in the same century, the wire ligature became very popular and was universally used. This was a crude antecedent of our present day snare operation. Celsus, born in 25 B.C., gives one of the first accounts of tonsillectomy, being criticized severely because he advocated the removal of tonsils with a knife. Fabricius condemned the knife because of the danger of hemorrhage. Paulus Egenita recommended the use of a hook and bistoury, but for the same reason of hemorrhage it was discarded. The actual cautery attempted to solve the problem met with but little favor. Following this, slow acid caustics came into vogue and were used for several centuries. The ligature method was employed in America until about 1830. This consisted of encircling the tonsil with a silver wire which was drawn tight and left in place to be tightened daily until after four or five days, the tonsil was severed. This procedure was so extremely painful that it fell into disuse. As late as 1828 Dr. Alexander E. Hosack of New York returned from France, where he had seen tonsillectomy performed by knife dissection. The operation was quickly done, and with a small amount of hemorrhage. He performed

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four of these operations, publishing his comments under the title "Remarks on the Various Modes Usually Adopted for the Removal of Tonsils."[2] Dr. Physick of New York condemned the method as very dangerous. So we submit that, aside from more perfect instrumentation, improvement in technic and asepsis, diathermy is the only method which would even have satisfied the throat specialist as far back as two thousand years.

Now, why do we wish to supplant the present surgical tonsillectomy which has received such universal approval, and which has been used for so many years? I believe the entire profession recognizes that there is no operation which has so many serious complications when they do happen as does the surgical tonsillectomy. It is indeed a major operation, with such complications as hemorrhage, primary and secondary, shock, pneumonia, lung abscess, often with gangrene of the lungs, and attending dangers always present from either general or local anesthetic, secondary infections, trauma to soft tissues, accompanied often by edema, sloughing, the later disagreeable effects from scar tissue, embolism, etc.; these are all too well-known to necessitate a detailed discussion here.

Harlow Brooks of New York is quoted as saying that he will not advise any of his patients over forty years of age to submit to tonsillectomy. Judson DeLand of Philadelphia in a paper read before the American Academy of Ophthalmology and Otolaryngology at Montreal, Canada, says that many physicians and laryngologists fail to recognize the etiological relationship of the removal of infected tonsils to pneumonia and pulmonary abscess, and that they occur more frequently than is generally believed, and may occur one or two weeks after the operation, and in such cases the causal relation to tonsillectomy is frequently overlooked. He adds that a technic should be devised so that the duration of the operation and the anesthesia is reduced to a minimum (lessening the shock and risk of absorption or aspiration of pathogenic microorganisms).

Chevalier Jackson, of Philadelphia, in a paper on the subject of post-tonsillectomic pulmonary abscess,[3] says: Myerson found blood, bronchoscopically, in 26 out of 100 cases of tonsillectomy. As the source of the blood was in the tonsillar field of operation, the inference is justified that the blood carried with it infective agents from the tonsil. Fetterolf placed mortality in cases of post-tonsillectomic pulmonary abscess between 25 and 50 per cent. Wessler found that 80 per cent of postoperative cases of pulmonary abscess in his experience had followed tonsillectomy. Lord found that out of 96 cases of lung abscess 78 were due to operation about the upper respiratory passages, and 49 of these followed tonsillectomy. All of these were performed under general anesthesia. Jackson follows this with a plea for more careful technic in preparation of patients, minimum of anesthetic, elimination of time wasting, the avoidance of trauma, use of low head position, and many other details, showing his great concern in this one serious complication of tonsillectomy. The Mayo Clinic reported in 1924 that 31 per cent of postoperative cases of lung abscess followed tonsillectomy under general anesthesia; but that in 16,000 tonsillectomies under local anesthesia, and in 4000 children under general, they only had 2 cases of lung abscess.

In the Bordeaux Clinic, France, no lung abscess follows tonsillectomy, and it is maintained that this is because they operate only with local anesthesia on adults, and use chloroform for children.

It is my firm conviction that 75 per cent of the dangers attending surgical tonsillectomy in adults would be removed if they were all performed under a local anesthetic, and if any surgeon who is not skillful enough to quickly remove tonsils under local, or whose method is so severe that the patient could not stand the pain, should either change his method or

try to become a more skillful operator. Next to hemorrhage, I consider pneumonia and lung abscess the most serious complications attending surgical tonsillectomy. I feel that there is too great neglect on the part of the surgeon in not following up the after-history of these cases. I know a surgeon who says he has not lost a case following tonsillectomy in twenty years. Yet in fourteen days after he had operated on a young man, the patient died from gangrene of the lung, diagnosed as such by an eminent lung specialist, who placed the responsibility entirely upon the operation. We know that the so-called ether pneumonias are simply pneumonias caused by the aspiration of infected material from the tonsil which is expressed by the manipulations of the surgeon and is taken into the lung during anesthesia.

Another serious complication to which little notice, if any, has been taken, and which may happen one or two years after the surgical removal of the tonsil, is an infection or reinfection of the myocardium caused by the flooding of the blood stream with microorganisms at the time of operation.

Dr. Mayer of New York conducted an inquiry a few years ago asking for a report on the complications and deaths from local anesthetics. This was of decided benefit to the profession, in that it brought to their attention most vividly the dangers from these anesthetics if carelessly administered. I would like to suggest that the editor (who stated some time ago[4] that diathermy of tonsils was not sufficiently proved and was often dangerous) conduct a questionnaire and have a reply from everyone doing surgical tonsillectomy as to the number of serious hemorrhages, pneumonia, lung abscesses and deaths they have had during the past year. I will venture that the results would be most alarming, and that if the public became cognizant of these facts, our surgical tonsillectomy would not hold its place numerically very long, and I believe the profession would have its eyes opened to this so-called simple operation.

I feel so keenly and profoundly on this subject of the hazards of the surgical procedure, particularly when after five years' experience with tonsillectomy by diathermy, I know that they can all be avoided, and to some extent I feel that this is borne out by the profession itself when you see how difficult it is to get a doctor, and particularly a throat specialist, to submit to this operation. I have removed more tonsils from doctors in the past two years by diathermy than I have in the previous twenty years by the surgical method.

I feel that, as I am asked so frequently what we do about children's tonsils, a word here would not be out of place. Most children from seven years of age and older readily submit to diathermy treatment. I am now treating a child of five years, but after the first two treatments she "got wise to us" and we had to resort to gas and oxygen. I would not attempt any other anesthesia in these cases, as I consider them too dangerous on account of their explosiveness.

I do not believe in the promiscuous wholesale removal of tonsils in children as practiced today. In the first place, as a general rule, children's tonsils, if infected at all, are either on the mucous membrane or in the very superficial part of the tonsil. We usually find Streptococci viridans in children's tonsils, whereas we find the Streptococci hemolyticus in the adult tonsil. If the child's tonsil is so hypertrophied as to obstruct the throat, we believe in a purposeful tonsillotomy, removing the portion of tonsil extending beyond the anterior pillar, thus leaving a portion of the tonsil to carry on whatever function nature has intended it to perform.

I have in my notes from Prof. Portmann's lectures in Bordeaux, France, his theory of the function of the tonsil. He believes that from the various bacteria that are collected in the tonsil, a vaccine is manufactured which goes into the

circulation of the child and protects it from the toxins which are constantly getting into the bloodstream, thus protecting the child during its development and growth, who when having arrived at puberty, does not need this protection further, and nature has intended then that there should be a progressive atrophy of the tonsil. This atrophy of the tonsil in later years after puberty proves that the function of the tonsil is only during childhood. This I consider about the most logical theory of the function of the tonsil. If this is true, are we not weakening the child's resistance by the removal of the tonsil, except in those cases in which the infection is severe and is causing systemic reactions?

Four years ago in a paper read before the Allegheny County Medical Society of Pittsburgh I made mention of the close relationship existing between the tonsils and the thyroid, and further that we knew the thyroid was intimately connected with the ovaries, testes, and other glands, and asked the question then whether or not the removal of the tonsil could affect the sexual organs. At that time this suggestion caused not a little amusement, particularly among some of our younger surgeons, but I find that E. Bates Block[5] reports that in a patient, a boy eight years of age, who had his adenoids and tonsils removed, the testes (which were normal up to that time) entirely disappeared.

I consider the removal of tonsils in children a very serious problem, and as it has been reported that 33⅓ per cent of all operations performed in our city hospitals today are tonsillectomies, I think it behooves the profession not to treat too lightly the now prevailing opinion that probably all children's tonsils should be removed.

As a further thought, Warthin, an eminent pathologist of Ann Arbor, has been quoted as saying that 60 per cent of all tonsils submitted to him after enucleation, he found to be normal. According to Kaiser's exhaustive experiment, in which he took 1200 operated cases and 1200 non-operated cases, his report[6] after a period of three years showed that there was very little difference in the physical condition of the two groups. One more suggestion in connection with removal of tonsils and adenoids in children. I am positive that a great number of tubotympanic catarrhal cases occurring in children is due to the fact that the tonsils and adenoids are removed at the same time. This can in a large measure be averted if the adenoids were removed four or five weeks after the tonsil operation. When done at a single sitting, we have three large infected areas which of necessity must extend into the eustachian tube. Thiebauld[7] reports from a survey of a large number of school children that 33 per cent had tubotympanic catarrh after the removal of tonsils and adenoids.

Now as to our method of choice (tonsillectomy by diathermy), it is not so new in Europe, where it has been used for at least twenty-five years, but mostly not as a routine procedure, but in selected cases. Doyen, of France, used it twenty years ago. Moure and Portmann of Bordeaux have been using surgical diathermy for fifteen years for many purposes, one of which is the coagulation of the tonsil. I have a report made at the request of the Academy of Medicine in Paris by Portmann of Bordeaux, Bourgeois and Poyet of Paris, and Lamothe of Limoges, for the year of 1924, of some seventy pages, which deals only with otolaryngological diathermy, in which they state diathermy of tonsils is very satisfactory.

We shall not enter into any lengthy discussion as to the physics of diathermy or its different methods of application. There are two kinds of diathermy, medical and surgical, both derived from high-frequency current discovered by Nagelschmidt. Diathermy was named by D'Arsonval who experimenting with Nagelschmidt's coils, found a combination that would make heat pass through a body;

hence, the name diathermy. The only difference between medical and surgical diathermy is the difference in the degree of heat registered. The so-called radio knife, which should be more properly called diathermy knife and the needles used in the coagulation carry the D'Arsonval current, which is very high in amperage and low in voltage. With this current there is extremely rapid action. Some who are advocating the dessication of tonsils use the Oudin or cold current, which is very low in heat and extremely high in voltage. I shall not discuss the dessication method, but I would as soon risk the surgical removal of my own tonsils as to have them dessicated. D'Arsonval says that we are but at the dawn of the use of high frequency in surgery.

Howard Kelly[8] says:

> In spite of an evident slowly growing appreciation of the value of electro-surgery, the extensive application of this new principle still remains limited to the few more or less specializing in this field. My present plea is for its wider adoption as indispensable in our daily practice as general surgeons, in all our hospitals, and above all in our teaching centers, that our young men may catch the inspiration of these radically new methods and carry them on to perfection. The difficulties are those of all new ventures; as established, successful general surgeons naturally grow set in their ways and look askance at radically new principles. The notion is also curiously current that electro-surgery is but another, perhaps somewhat more convenient and refined way of using the ancient hot iron and therefore, negligible to that extent. An added objection of the prima facies sort is that it calls for switchings and sundry manipulations which are sources of delays and inconveniences. Further discouragement follows the discovery that it is after all not quite so easy of effective application as anticipated. Noting these and other objections and making my most conciliatory bow to the objectors, I still insist that our younger men, with pliable brains and flexible fingers, should be given every chance to take the matter in hand and judge for themselves, for I have a supreme confidence that once turned into these inviting new channels, they will develop a refined and efficient surgical technic which will astound the next generation and help to mark a new era. Let me here stake any reputation I may have for prophetic vision and let the future decide.

Harvey Cushing of Boston is opening up a wide field for electro-surgery in brain and neural surgery, and Walter E. Dandy of Johns Hopkins is advancing on similar lines. It takes but little imagination to envisage the numerous applications possible here.

Kolisher and many others among leading urologists have for years been using diathermy in the coagulation of papillomas of the bladder, which they claim is so superior to the old method with the knife, because with the coagulation method there is no return of a papillomatous condition. If the general surgeon, the gynecologist, the brain surgeon and the urologist speak in such glowing terms of the great usefulness of diathermy, and put it in a class with the knife, radium and *x*-ray, is it not high time for the laryngologist to recognize the fact that this powerful agent will remove easily, quickly and safely, the small mass of lymph tissue located in the fauces known as the tonsil.

To describe the technic of the application of diathermy to the tonsil, instruments used and the proper setting of the machine, is simple, but the actual application of the current to the tonsil is more difficult than one gathers from the description. The high frequency machine is of great importance. It should have not less than a million and a half oscillations a second, and I prefer one with Leyden jars, insuring a smooth, soft current, without spark or shock to the patient. The next important feature is the adjustment of the machine, which is done in the following manner: Take three-fourths of rheostat setting of machine; make a dead short between the two voltage or surgical diathermy connections, and before turning on the machine, see that the spark gap is closed; after this turn on the machine and open spark

gap gradually until you get a meter reading of 2800 ma.; then take one of the diathermy cords and connect to a piece of heavy block tin 6 in. by 10 in., which is placed upon the patient's back. The second cord, which holds the needle, is attached to the other surgical diathermy outlet. Now you have set the machine before the operation, and an amperage necessary to give coagulation has been definitely fixed. As the tonsil is made up of lymphocytes with very little organized tissue, it is speedily and easily destroyed by this amperage. The consideration of importance is the time of contact with the tonsil and the active electrode or needle. (Nothing but a needle should ever be used, and see that the rubber sleeve covering it is pulled up over the end of the handle, so as not to spark the tongue.) The time is not limited by seconds, but by the reaction of the tissues to the active electrode or needle; when the point of coagulation is reached, a white ring appears around the needle. This requires from one half to two seconds, never longer. These are the three important factors in the technic; first, setting the machine; second, type of active electrode; third, time of contact.

Now, as to the method of applying this to the patient. This is an office procedure. The patient is seated in any kind of office chair desirable, and a large piece of the heaviest block tin, 6 in. by 10 in., is applied to the bare skin of the patient's back and connected by an insulated cord to the machine. I use a 5 per cent solution of cocaine, having wet the cotton on the applicator only once with the solution. This I quickly apply to the soft palate, around the tonsil, inside the cheek and the base of the tongue, repeating this procedure five or six times with the same pledget of cotton, but no additional cocaine. I use no more than 4 or 5 drops for the whole procedure. Now the throat and tongue are sufficiently anesthetized. I have never had a patient faint or show the slightest sign of syncope in 23,000 applications. I treat many cases without any anesthetic whatever.

I never inject novocaine for three reasons. First, there is the slight danger from the anesthetic; second, more fluid is added to the field which you wish to dehydrate; third, you get about as much reaction from the fluid injected into the soft tissues as you do from the diathermy. (Use a wooden or glass tongue depressor; further, always have a nurse hold forward the anterior pillar with a hard rubber pillar retractor; never turn on the current unless you can absolutely see the exact location of your needle. If there is one point more important in the technic than another, it is knowing where the point of your needle is, and it must always be turned more or less toward the center of the tonsil.) Now I take the needle, the end slightly curved, and put it from ⅛ to ¼ in. into the tonsil, and step on the foot switch, and in from one to two seconds the white ring appears around the needle. Release the current and take out the needle. This procedure is repeated until the tonsil has been covered with punctures about ¼ in. apart. The number of punctures varies according to the size of the tonsil; I often use on large tonsils as many as twelve to fifteen. I now paint the tonsil with some acriviolet, and the patient goes right on with his usual routine of the day.

My usual practice with patients who live in the city is to treat only one tonsil at a sitting. In seven or eight days the patient comes back, the tonsil operated upon has 50 to 75 per cent disappeared, and the other tonsil is treated. Both tonsils can be treated at one sitting and can be entirely removed with one treatment, but I strongly advise against this, as there will be greater reaction, and the patient is more uncomfortable than when only one tonsil is treated at a time. I prefer giving four to six treatments to each tonsil, and they are removed with no great inconvenience. I have not had more than four or five patients who have gone

to bed for a day, or who have had any elevation of temperature, or who missed a single meal, or any time from school or business. I have used diathermy in many cases of acute tonsillitis with splendid results.

The third, fourth, fifth and, if necessary, the sixth treatments, are each distinctly different. You are working in less tissue, necessarily nearer the other throat structures; hence the need for greater care as to depth of penetration of needle. And once more I want to emphasize the constant care as to where the point of the needle is. The last treatments often consist of only two or three punctures, and the last tissue that may be adherent to the posterior pillar can often be best removed by simply laying the belly of the needle against it and slightly coagulating it. I want again to call attention to the special instruments I use. First, a short, pointed, curved needle. This enables one to hook into and slightly elevate the tonsil from its pocket. The needle is used in a handle that locks it and prevents its turning, so one can always tell where the point is. Second, a glass tongue depressor. Third, a hard rubber pillar retractor, to be used by an assistant in each step of the various treatments. The anterior pillar must be retracted and kept away from the needle, or there may be coagulation and extensive edema. It is these seemingly minor, unimportant things that make for the success of the method. And once and for all, remember that electro-coagulation is not electro-dessication or fulguration. From both of the latter methods there is scar tissue, and very unsatisfactory results.

Just a word as to the chief objection I hear raised to the diathermy of tonsils: "You can't remove all of the tonsil and capsule." I defy any anatomist to demonstrate a capsule of the tonsil. We have talked about it so long that we really now believe in its existence. When the tonsil is removed, you have a clean fossa with the anterior and posterior pillars intact, and you are down to the aponeurosis of the constrictor muscles. I am daily removing portions of tonsils left by some former tonsillectomist. Why all this fuss about the diathermy method not removing the tonsil entirely, when it was reported recently in one of our journals that 76 per cent of all tonsillectomies were not clean?

Diathermy is suitable for the removal of all kinds of tonsils and in all cases, regardless of the diseases from which the patients may be suffering. There is no serious condition that I know of which contraindicates the use of diathermy in the removal of the tonsil. I have treated a patient who had been confined to her bed for eight months with rheumatism complicated by a severe heart condition, also a goiter, who, after the removal of her tonsils by diathermy, in a couple of months was convalescing and walking around her room. It is a great pleasure to be able to restore children to a more reasonable degree of health by diathermy tonsillectomy, who have been suffering from nephritis, pyelitis or heart affection. The more important diseases which are considered contraindications to the surgical tonsillectomy are hemophylia, tuberculosis, nephritis, heart lesions, acute syphilis, etc. These are all admirably suited for diathermy. I have had 6 or 8 cases of hemophylia. I removed the tonsils in these patients without loss of a single drop of blood. Another large class of cases are the adults who perhaps have been suffering for years from the effects of diseased tonsils, and who will not submit to the old orthodox operation, as they realize the risks of this method, but they are coming rapidly to diathermy. The profession cannot long afford to continue a method that does have serious complications and too many deaths without giving a new method that is absolutely safe a fair hearing.

One more word of caution as to the technic. The tonsil cannot be eradicated in two or three treatments without a great deal of serious reaction, often times

tremendous edema and a great deal of suffering, or with possible confinement to bed. Our method of treating each tonsil five or six times has been devised for the comfort and safety of the patient, not for the convenience and time-saving of the surgeon. If you want every afternoon for golf, do not take up diathermy. Further, I consider that more skill and a better knowledge of throat anatomy are required to perform a diathermy of the tonsil than to do a surgical tonsillectomy. One more caution. In every treatment you must have an assistant retract the anterior pillar, as the slightest coagulation of either pillar causes tremendous edema and excruciating pain, but a proper technic skillfully executed gives nothing but success to a very grateful patient.

Before closing this paper, I wish to call attention to the editorial by Shambaugh[9] on my article[10] where he states that, "as [my] method is so difficult that others working with it fail to get satisfactory results, it is an argument against the procedure." I have never stated that the technic was difficult, but that the technic must be carefully and patiently followed out, and that you must have an intelligent grasp of the agent you are using, and the proper knowledge of the anatomy of the throat in which you are working. If the editor's objection to the difficulty of the procedure was to be seriously considered, Harvey Cushing would have to give up brain surgery, gall bladder operations would be discontinued, a safety pin would have to be left in the bronchi, because these, with other surgical procedures too numerous to mention, are very difficult, and require a great deal of skill and experience on the part of the operating surgeon.

He further states "he has seen patients that have been treated by this method, where the instance of recurring infection in the tonsil fossae still persists." If he wants to be fair, why does he not also state that from his large experience he has probably seen thousands of cases where recurring infection persisted after the surgical tonsillectomy. I think we all court constructive criticism.

I have already called attention to the intimate relationship existing between the tonsils and other glands of the body. This has led me to the question of whether or not the prevalence of goiter in girls of high school age may not be due to the early removal of tonsils. I am going to try to have a short survey made of this subject, and am simply mentioning it here with the hope that others may make a similar observation.

The technic and instruments that we are now using are the results of a gradual development during the past four years, in the removal of more than 2200 tonsils, which has necessitated the use of about 60,000 needle punctures. From this experience I feel sure that the advice given in the foregoing will bring the most satisfactory results to the patient and the surgeon. This method makes the removal of tonsil remnants and the lingual tonsil very easy, and free from any danger of hemorrhage.

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TREATMENT OF SYRINGOMYELIA BY ROENTGENTHERAPY*

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HISTORICAL REMARKS

THE first successful reported case of *x*-ray treatment of syringomyelia was published in 1905 by Profs. Raymond, Oberthur and Delherm,[1] who during more than a year had kept up roentgentherapy over the spinal cord in a young woman and had achieved an improvement of both the motor and sensory disturbances.

The happy effects of this treatment were immediately confirmed by a number of authors: in 1906 Gramega,[2] Ronzoni[3]; in 1907 Menetrier and Béclère, Beaujard and Lhermitte[4]; in 1908 Holmgren and Wiman,[5] Gavazzenni,[6] Delherm,[7] Desplats,[8] Bienfait[9]; the same year marked the appearance of the thesis of Labeau[10] who reported 6 observations of patients suffering from syringomyelia, treated by roentgentherapy with varying results. In 1909, we find the work of Nobele;[11] at that time, because the new method had run aground in some cases, and because in other cases it had sometimes given doubtful results, there was a growing tendency to regard with doubt the efficacy of *x*-ray therapy. Nevertheless, in the course of this year Profs. Raymond, Oberthur and Delherm[12] were able to complete the observation of the young woman whom they had reported as treated with success in 1905, four years before, and to demonstrate that the improvement which they had obtained at that time persisted; so that they were able to establish a difference between a spontaneous remission, occasionally observed as a temporary exhibition in the course of the disease, and the durable results following roentgentherapy.

We come then in order upon the work of Raimbaud,[13] and Beaujard[14] in 1910; Allaire and Denes,[15] Marques, Roger and Beaumel,[16] Huet and Sahatchieff[17] in 1912. Among other important articles appearing in 1912 were that of Bourguignon and Thomas[18] who sought to standardize the technic and insisted on the necessity of making the field of irradiation considerably wider and higher than the presumed site of the lesion, and that of Sahatchieff[19] who was able to collect observations on 6 unpublished cases studied by himself, and finally that of Rupin[20] who devoted his inaugural thesis to this question.

Then for several years it seemed that interest in this subject lagged. Not until 1919 do we find the thesis of Saignol,[21] and it was not until 1921 that new observations began to appear in numbers. Among them we may refer to the following: in 1921, Bourguignon,[22] Lhermitte,[23] Bonnet,[24] and especially Coyon, Lhermitte and Beaujard[25] who had the privilege of reporting observations on some patients who had been treated several years before and in whom the improvement obtained then had persisted; furthermore, they were the first authors to publish autopsy findings permitting a control of the efficiency of their treatment.

In 1924 Menetrier and Deville[26] were able to relate the case of a subject treated for syringomyelia twenty years before, and who, as was remarked by Béclère[27] in the discussion, had been treated with "penetrating but not deep" roentgentherapy. The same year Merrill[28] reported a case treated with success, and in 1925 Froment, Japiot and Josserand[29] reported a favorable case.

The number of observations reported in 1926 is considerably larger; 14 cases are credited to Ossinsky and Guise,[30] 14 to

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Charapow,[31] 2 to Wielski and Artwinski,[32] 53 to Keijser,[33] 13 to Heinismann and Czerny,[34] 4 to Proust, Mallet and Coliez[35] who had utilized deep therapy, and 1 case to Coliez and Rebuffel[36] who had been able three years after treatment to demonstrate persistence of the improvement obtained.

Thus we find many authors in agreement that considerable progress has been made in the employment of *x*-rays in the treatment of spinal cord affections, and especially in the management of syringomyelia, although the various therapeutic measures in use before the commencement of roentgentherapy have remained practically useless. On the contrary, roentgentherapy is not simply a symptomatic remedy; it presents all the advantages of a therapeutic means which is always palliative, sometimes even curative. As far back as 1912 Sahatchieff,[17] after studying the published cases then amounting to about 30, estimated that in 80 per cent of subjects suffering from syringomyelia improvement had followed roentgentherapy. In the literature, which we have carefully examined, we find no statistical summary later than the one just mentioned; but we think we are not far from the truth in estimating at 150 the number of cases published since 1905. To these we may add 16 personal cases in our service of Electro-Radiology at the Hôpital de la Pitié. After a brief resume of what constitutes syringomyelia we shall see what deductions seem justified from the facts having a bearing on the indications, the technic and the results of roentgentherapy, after which we shall summarize and discuss our personal cases and see what deductions are warranted.

CLINICAL CONSIDERATIONS

From the clinical point of view syringomyelia constitutes a syndrome which is manifested by the sufferers in different degrees of disturbance of the various motor, sensory and trophic systems, and which in classical cases bursts suddenly upon the masculine sex at adult age, without the origin of the affection having yet been determined.

Sometimes, but already at an advanced stage, syringomyelia manifests itself by a characteristic aspect, the symmetrical atrophy of the two hands being accompanied by disturbances of sensibility of different kinds. Under such circumstances one immediately thinks of syringomyelia, but often the attention is called to the true nature of the malady only after a complete methodical examination of the various aberrations of the nervous system.

All degrees of motor disturbances are to be recognized: at first the delicate movements of the fingers and hands become difficult, then impossible, till at last these patients cannot write, sew or play the piano; then the disturbances extend to the arms, so that the patients cannot any longer raise the arms sufficiently to comb their hair or raise food to their mouths. These symptoms are due in part to a true paresis, in part to the muscular atrophy which suddenly appears upon the thenar and hypothenar eminences and the interosseous spaces which melt away, giving to the hand the aspect known by the classical expressions monkey hand or teacher's hand. Subsequently there supervene the tendinous retractions which provoke the flexion of the fingers and bring about the appearance of a claw (*griffe cubitale*).

The atrophy may invade the entire arm, the shoulders, and even the lower limbs; rarely it involves entire muscles, but it proceeds especially by muscular bundles and is often accompanied by fibrillary jerkings. It is generally observed that the lesions are symmetrical.

Along with these symptoms one should pay considerable attention to the trophic disturbances: those which affect the teguments, local asphyxia, puffiness of the hands, dryness of the skin. Still more particularly symptomatic is the appearance of analgesic panaris or painless ulceration of the tips of the fingers, very important from the point of view of diagnosis. But these troubles may also

invade bones and joints, provoking rarefying or hypertrophic osteitis or various types of arthropathy, among which one should mention the existence of a frequent and precocious dorsal scoliosis which plays a very useful diagnostic rôle.

One may call the sensory disturbances constant; they are observed especially at the level of the upper limbs; they are almost characteristic. The sensation as of ants creeping upon a part, tingling and burning of the affected extremities constitute the subjective troubles. But the capital point of the examination consists of the search for the objective troubles: loss of pain and temperature sense constituting the syringomelic dissociation, and more or less perfect preservation of the sense of touch. The existence of these troubles and their localization give, at least in a certain measure, an idea of the extent of the medullary lesion, to which one cannot attach too much importance in view of the treatment which should be administered. One should know further, at least during the initial period of the disease, that the sensory symptoms present a radicular disposition.

As a general rule, syringomyelia, when not treated, passes through successive stages of evolutionary activity separated by periods of remission susceptible of prolongation over considerable time. It is very important to recognize these periods of arrest of the disease which make it self-evident that only prolonged observation of patients undergoing treatment will permit a judgment of the efficiency of the treatment.

The principal symptoms which we have just described pertain to a typical syringomyelia; in reality the disease can be manifested under a multitude of clinical aspects essentially variable according to the localization of the pathological process. And because the pathological process may extend anywhere from the upper to the lower extremity of the cord and give rise to all kinds of serious symptoms, every case of syringomyelia should be considered from the therapeutic point of view as a very extensive lesion which necessitates an irradiation exceeding by a good deal the region suspected of harboring the glioma, and which in certain cases means that the entire spinal cord must be irradiated.

DIAGNOSIS

According to the clinical aspect of the individual case, the diagnosis of syringomyelia will present a more or less different problem.

It is particularly easy in the typical forms when one discovers the characteristic trophic disturbances: a symmetrical atrophy of the extremities, a painless panaris, and a clear thermo-analgesic dissociation.

On the contrary, the diagnosis is not always easy, especially in the early stages of the disease where the diagnosis demands a profound knowledge of neurology. It seems to us indispensable to emphasize the importance of excluding, because of their similar symptomatology, disseminated sclerosis and amyotrophic lateral sclerosis.

Cervical hypertrophic pachymeningitis, a condition often associated with syringomyelia, may by itself give rise to a clinical picture quite analogous to that of syringomyelia and lead to error. Often also by the clinical manifestations alone it will be impossible to recognize a meningo-medullary syphilis; one will have to fall back on serum reactions, and sometimes only the therapeutic test will permit the dissipation of doubt.

Finally, leprosy and Morvan's disease present with syringomyelia such similarities that certain authorities have desired to consider them identical.

When the diagnosis of syringomyelia has been made, it seems to us that two points merit particular attention:

1. *What is the etiology of the affection?* At the present time we are not in a position to give a satisfactory answer to that question; if this could be determined, it would be possible to anticipate the action

of the irradiations. Lhermitte says: "At present it is impossible to say whether the syringomyelic syndrome is due to a gliomatous or hydromyelic process, or to a pachymeningitis complicated with excavation of the medulla; only complete failure of radiotherapeutic treatment could lead to the diagnosis and justify the belief that we are not dealing with a neoplastic process."

2. *What is the extent of the lesion?* For a knowledge of this extent we depend most of all on the study of the anesthesia and its radicular topography; but this means affords us only insufficient data, and we should always suspect more or less extensive adjacent involvement.

PATHOLOGICAL ANATOMY

It may be of value in explaining the action of the *x*-rays, if we review rapidly the anatomical and pathological facts regarding syringomyelia.

The syringomyelic always show important lesions of the cord. In the high lesions involving the cervical cord, most often with cervical swelling in the Aran-Duchenne type and with swelling of the lower part of the cord in the paraplegic types, the cord assumes the appearance of a soft sac which bursts after its liberation.

Indeed, anatomically the lesions resemble an excavation in the cord which is characterized histologically by neoplastic tissue, glioma. This cavity sends prolongations upward and downward possibly reaching to the bulbar region or to the terminal enlargement; we have already mentioned the possibility of the existence of these prolongations, which are very important from the standpoint of the treatment.

The glioma includes cells with fine prolongations (spider cells) and fibrils infiltrating the zone between the ependymal canal and the posterior horn.

Sometimes the cavity is formed at the expense of the ependymal canal, the epithelium of which preserves its normal character; sometimes, as in the associated pachymeningitic type, the thickened dura mater compresses the cord and the arachnoid spaces are partially compressed by the neoplastic tissue.

In brief, whatever may be the case as to the nervous lesions, there exist two outstanding processes affecting the organs: compression and destruction.

While in the latter, it is hopeless to expect a useful repair of the tissues as an effect of the treatment (it is known that *x*-rays do not repair); nevertheless it is logical to think that by causing an arrest of the compression, it may result that the nervous elements, freed by the action of the radiation, may regain a certain degree of vitality and activity. It is this possibility which should guide us in the application of the treatment, which we shall thus be most eager to undertake as early as possible, in the earliest stage of the disease.

ACTION OF RADIATION

There is no doubt that if we knew exactly the pathogenesis of syringomyelia, the results of our treatment would improve in precision and efficiency; unfortunately, we are not at all able to affirm that the lesions which present themselves to us under such variable aspects involve different pathogenies; but we well know how the action of *x*-rays varies according to the nature of the neoplasm.

Hoffmann has advanced the hypothesis of an embryonal origin based upon the coexistence of spina bifida and supernumerary ribs with the syringomyelic lesions.

Guillain has invoked the influence of traumatism.

Other authors, because the site of the spontaneous or traumatic hematomyelia is at the level of the base of the posterior horns, have thought they could associate with this a possible origin of the affection.

Nevertheless, in the opinion of most authors, syringomyelia is due to the development of an intramedullary gliomatous tumor. Since gliomatous tissue is composed of young and relatively differ-

entiated cells, of great cellular activity, the *x*-rays are capable of exercising on these cells a very pronounced action (Baldwin, Beaujard, Lhermitte), while the adjacent nervous tissue, like the lesions of cicatricial sclerosis, offer in contrast a very considerable radioresistance. It is not less true that the rays cannot destroy all the gliomatous cells, and that some of them can exist in an inactive state for an indefinite period, as has been shown by Bienfait.

Furthermore, whatever may be the pathogenesis of the affection, it should not be forgotten that the law of Bergonié-Tribondeau determines the result of radiation therapy: while it can be efficient in lesions made up of young cells in process of evolution, it can hardly succeed with fibrous lesions of slight radiosensibility; on the other hand, while it can provoke an arrest of the progress of the disease and even bring about a regression, sometimes of considerable degree, often diminishing the observed troubles, it cannot in any case reconstruct that which has been destroyed; hence the declaration of Ossinsky and Guise,[30] "There can as yet be no question of complete cure."

RESUME OF THE CASES OF SYRINGOMYELIA TREATED BY X-RAY

We have tabulated the various cases of syringomyelia treated by *x*-ray which we have been able to find in the literature, showing the patient's age at the outset of the disease and the approximate duration of the evolution of the affection before the treatment was instituted (Table I).

If we compare the various data furnished by this table we can at once conclude that the treatment seems to offer the greatest chances of success in the presence of a relatively recent involvement. When of several years' standing syringomyelia seems less and less vulnerable, and an evolution of eight to ten years seems to render it entirely resistant to the treatment.

A case reported by Sahatchieff seems to constitute an exception to this rule (Case VI, a woman of fifty-three years, the disease beginning only four years before the commencement of the treatment), but there remains some question; an onset of syringomyelia at such an advanced age seems rather late, and one may suppose that the affection remained unrecognized for a long time; furthermore, the patient, a domestic, on her admission to the hospital showed marked atrophy of both hands and forearms with limitation of movements of the elbows and of abduction and of elevation of the arms, and it was during the very course of the treatment that the aggravation of the symptoms was marked.

Reviewing the results furnished by the study of this table, we see that while, on 53 cases observed, Keijser reported 60 per cent of improved patients, the 91 cases treated by various other authors furnished 82 cases improved (about 90 per cent), 6 cases arrested or worse (about 7 per cent), 2 cases doubtful (about 2 per cent).

We personally have had the opportunity of treating 22 patients; 7 of them who simply received a few séances of roentgentherapy we have not included in our study which will therefore deal only with the 15 cases treated in the course of recent years, and which for the most part have been referred by Dr. Babinski who has continued to follow them clinically.

In Table II, where our personal observations will be found, we have adopted the same classification as in the preceding table.

RESULTS OBTAINED BY ROENTGENTHERAPY

In a general way, in agreement with numerous authors who have been interested in this question, we have been able to determine that regression of symptoms in the favorable cases, at least as concerns the painful phenomena, begins rather early under the influence of the treatment. We wish to emphasize a rather parodoxical observation recorded by Charapow[31]: the reestablishment of sensibility to pain, at first rapid in the old cases, subsequently

TABLE 1
CASES OF SYRINGOMYELIA TREATED WITH X-RAYS

Authors and Date	Age at Beginning. Sex	Duration of Evolution before Treatment	Duration of Treatment	Results Obtained on the Symptoms
Raymond, Oberthur, Delherm, 1905..	22 years, F.	5 years	1 year	++ Motor and sensory, persisting after 5 years.
Raymond, Oberthur, Delherm, 1905..	?	6 years	1 year	++ Motor and sensory
Ronzoni, 1906.....	?	?	?	++
Gramega, 1906, 2 cases.....	42 years, M.	1 year	1 year	++ Motor and sensory
	16 years, F.	A few months	1 year	++ Motor and sensory
Menetrier, Béclère, Beaujard, Lhermitte, 1907	23 years, M.	3 years	11 months	++ Motor and sensory
Gavazzenni, 1908.....	?	?	?	++
Holmgren, Wiman, 1908.....	51 years, M.	8 years	?	++ Motor and sensory
Labeau, 1908, 6 cases.....	46 years, F.	3 years	3 months	++ Motor and sensory
	42 years, F.	Several years	3 months	−−
	22 years, F.	2 years	1 year	++ Motor and sensory
	50 years, M.	15 years	Insufficient	−−
	57 years, M.	5½ years	5 months	++ Motor and sensory
	24 years, F.	2 years	4 months	++ Motor and sensory
Desplats, 1908, 2 cases.....	?	?	?	++
	?	?	?	++
Nobele, 1901.....	?	?	1 year	Doubtful
Bourguignon, Thomas, 1912.....	26 years, M.	4 years	4 months	++ R. D. persists
Allaire, Denes, 1912.....	30 years, F.	7–8 years	6 months	++ Motor and sensory
Marques, Roger, Beaumel, 1912.....	25 years, F.	4 years	3 months	++ Motor and sensory
Huet, Sahatchieff, 1912.....	47 years, M.	3 years	1 year	++ Sensory R. D. regresses
Sahatchieff, 1912, 6 cases.....	41 years, M.	5 years	1 year	++ Motor and sensory
	55 years, M.	3 years	1 year	++ Motor and sensory
	47 years, M.	4 years	1 year	++ Sensory
	27 years, M.	10 years	1 year	
	47 years, M.	3 years	(Observation of	Huet and Sahatchieff)
	53 years, F.	4 years	2 years	−−
Saignol, 1919.....	30 years, ?	8 years	1 year	++ Motor and sensory
Bourguignon, 1921.....	?	?	?	?

TABLE 1 (*Continued*)

Authors and Date	Age at Beginning. Sex	Duration of Evolution before Treatment	Duration of Treatment	Results Obtained on the Symptoms
Bonnet, 1921	? F.		Very long	++ Trophic persisting after 4 years
Menetrier, Deville, Béclère, 1924	26 years, M.	5 years	?	++ Motor and sensory persisting after 20 years
Merrill, 1924	24 years, F.	14 months	16 séances	++ Motor and sensory persisting after 6 years
Froment, Japiot, Josserand, 1925	?	?	?	++ Trophic
Ossinsky, Guise, 14 cases, 1926	23 to 46 years 8 F. 6 M.	2–13 years	Relatively short; deep therapy	++ All symptoms
Charapow, 1926, 14 cases			Small doses 12 to 18 H	++ 14 cases
Wielski, Artwinski, 2 cases, 1926		Short		++ 2 cases
Stormer, Bremer, 9 cases, 1926	39 years, ?	1 year	?	++ Motor and sensory
	41 years, ?	7 years	?	++ Motor and sensory
	23 years, ?	1½ years	?	++ Motor and sensory
	?, ?	?	?	Doubtful
	18 years, ?	10 years	?	−−
	27 years, ?	4 years	?	++ Motor and sensory
	15 years, ?	10 years	?	−−
	25 years, ?	7 years	?	++ Motor and sensory
	44 years, ?	Some months	?	++ Motor and sensory
Keijser, 1926, 53 cases			Deep therapy	+ 60 per cent
Heinismann, Czerny, 13 cases, 1926	20 to 56 years 2 F. 11 M.		Deep therapy	Motor and sensory
Proust, Mallet, Coliez, 4 cases, 1926			Deep therapy 5000 R	Motor and sensory
Coliez, Rebuffel, 1926	20 years, F.	3 years	Deep therapy 5 months	Motor and sensory
Claude, ?	59 years, ?	Some months	1 year	Motor and sensory

Note: In this table, the sign ++ signifies improvement; the accompanying phase indicates the symptoms improved. The sign −− signifies aggravation of the symptoms.

progresses only slowly, while just the contrary occurs in the recent cases.

Although Ossinsky and Guise[30] had been able sometimes to observe a transitory aggravation of the subjective disturbances at the beginning of the treatment (more lively pains, more pronounced weakness, more marked paresthesias, psychic depression), these generally seemed the first to be influenced and, in a large number of cases, disappeared after the first seances of radiotherapy. This is the case, for example, with the tingling, pricking and burning sensations; but we

TABLE II

PERSONAL CASES FOLLOWED

Sex and Age at Beginning of the Evolution of the Disease	Regions Involved	Duration of the Evolution before Treatment	Regions Irradiated. Duration of Treatment. Number of R Units Given	Results
F. 27 years	Quadriplegia	3 months	Cervicodorsal 4 months 7200 R	++ Motor and sensory arms
F. 23 years	Quadriplegia	12 years	Cervicodorsal 9 months 2400 R	++ Motor
M. 23 years	Arms	4 months	Cervical 13 months 3200 R	++ Motor
M. 20 years	Arms	15 months	Cervicodorsal 13 months 11,600 R	++ Sensory
F. 21 years	Arms	2 years	Cervicodorsal 10 months 4800 R	++ Sensory
M. 30 years	Quadriplegia	2 years	Cervicodorsal 2 years 2400 R	++ Motor
F. 41 years	Right arm	1 year	(1) Cervical 3 months 4800 R (2) Cervicobulbar 3 months 2400 R	++ Sensory and motor, but only after area No. 2
F. 24 years	Arms	16 years	Cervicodorsal 4 months 5600 R	++ Motor and sensory in part
F. 38 years	Right arm	21 years	Cervical 8 months 4800 R	++ Trophic
M. 41 years	Paraplegia and right arm	1 year	Cervical 16 months 8000 R	0
M. 55 years	Paralysis of the arms	4½ years	Cervicodorsal 5 months 4800 R	−−
M. 48 years	Paraplegia	4 years	Cervicodorsal 2 years 24,000 R	−−
F. 27 years	Paraplegia and left monoplegia	20 years	(1) Cervical 12,000 R (2) cervicodorsal 4800 R 6 years in all	−−
M. 35 years	Paraplegia	15 years	Cervicodorsal 2 months 2800 R	−−
M. 23 years	Quadriplegia	Congenital ?	Cervicodorsal 3 months 4800 R	−−

Table II (*Continued*)

Sex and Age at Beginning of the Evolution of the Disease	Regions Involved	Duration of the Evolution before Treatment	Regions Irradiated. Duration of Treatment. Number of R Units Given	Results
Memorandum of cases not followed (Disappeared)				
28 years	Legs	?	Dorsolumbar 3 séances	
40 years	Left hemiparesis	20 years	Cervicodorsal 3 séances	
63 years	Right hand	3 years	Cervicodorsal 4 séances	
53 years	Arms	Several years	Cervicodorsal 4 séances	
29 years	Right arm	.....	Cervicodorsal 6 séances	
40 years	Left arm	2 years	Cervicodorsal 12 séances 3000 R	
27 years	Legs	Some months	Dorsolumbar 6 séances	

Note: In this table the sign ++ signifies improvement; the accompanying phrase indicates the symptoms improved. The sign o signifies stationary. The sign -- — signifies aggravation of the symptoms.

should also remark that when a recurrence takes place, these are among the first symptoms to reappear.

These difficulties seem to arise from two causes: on the one hand a compression of the sensory pathways, on the other the muscular contracture which may result from compression of the motor bundles and which is palliated in proportion to the diminution of the subjective symptoms.

In just the same way there is an early improvement of the objective sensory manifestations; Charapow[31] has observed that the improvement of the thermic sense, chronologically the last to be manifested, sometimes can be preceded "either by a perversion of sensation or by a sensation of paresthesia" of a transitory character. Rather rapidly one may note a regression of the extent of the symptoms as a whole, beginning at the extreme upper and lower zones; nevertheless, it will be observed that this regression usually remains incomplete and affects only a small part of the involved regions, the greater part of which does not show any modifications.

In certain cases, following the first applications of radiotherapy, it is noted that the motor difficulties are favorably influenced; and this improvement which surprises the patient himself constitutes a valuable encouragement to pursue the treatment. If on noting this improvement we fail to make allowance for the phenomena in relation to the paretic manifestations and the contractures which may regress rapidly and even disappear completely, and especially to allow for the more marked symptoms due to the muscular atrophy, which are rarely modified, we may at least sometimes observe an improvement in the motor functions. And it is not rare to observe the recovery of the fine movements of the digits which had become impossible as long as there persisted a marked degree of muscular atrophy.

We should not overlook the rare symptoms of syringomyelia, such as sphincter or psychic troubles, which the treatment is capable of improving. Even more

remarkable is the influence of roentgen-therapy on the patient's general state; along with an improved sensation of well-being and of a return of strength experienced by these patients toward the end of a series of treatments, it is much more important to emphasize the objective manifestations of this amelioration, that is to say the return of appetite and the increase of weight.

As relates to the electrical reactions of the involved segments, when there exists a reaction of degeneration the abolition of faradic excitability as a general rule persists very definitely, and in only one case have we been able to note a progressive disappearance of the reaction of degeneration. On the other hand, when there is only a partial reaction of degeneration, we, like other authors, have been able to demonstrate a improvement of the hypoexcitability.

DISCUSSION OF OUR PERSONAL OBSERVATIONS

As already mentioned, we have made personal observations in 15 cases, which we propose to analyze. The age of the patients varies from twenty to fifty-five years. The duration of the evolution of the disease before treatment was three months to twenty-three years. The duration of treatment with the rays varied from two months to six years. Our statistics include:

Improved	9 (about 60 per cent)
Unchanged	1 (about 7 per cent)
Aggravated	5 (about 33 per cent)

The observations which we have recorded suggest a certain number of remarks:

I. *Aggravations:* These we have always noted in adults whose affection dated back several years: four, four and one-half, fifteen, twenty, twenty-three. In all these cases we observe that the upper half of the body had been involved.

The duration of treatment had varied from two months to two years.

Let us put special emphasis on 2 cases: (1) Case XII, that of a man of forty-eight years, suffering for four years it seems, and who had in two years received over the cervicodorsal region the rather large dose of 24,000 R. Because the symptoms had followed an accident, a fall from a height, it was supposed that in this case we dealt with a traumatic syringomyelia. (2) Case XI concerns a man who was fifty-five years old when his first symptoms appeared; it was not until four and one-half years later that he began his treatment. It is rare to note the appearance of syringomyelia at such an advanced age, and one may properly question (without any means of giving an exact answer) whether the disease had remained latent a certain time or whether by reason of slight clinical manifestations it had simply remained unrecognized.

II. *Unchanged:* We believe the remark just made regarding Case XI may be repeated under this heading, for in that case the treatment seemed without effect.

III. *Improved:* The improvements which we have observed have been met with in adults of twenty to forty-one years. The evolution of the disease before treatment seems to have lasted, at least clinically, from three months to twenty-one years. These patients have received doses of from 2400 to 11,600 R.

If we employ the word improved it is because these patients have not passed from our observation, and because to the apparent arrest of the disease process there has been added regression of certain troubles. We have made most careful note, not only of the subjective modifications from the clinical point of view, but especially of objective manifestations; and if we place emphasis upon the long duration of our observation of these patients, it is because we have already called attention to the fact that the evolution of syringomyelia is often characterized by periods of advance alternating with remissions. If these remissions can be prolonged to the point of permitting one to think of an arrest of evolution, it is natural to suppose that the life expectancy of these cases can

be greatly prolonged. This explains why the observation of Menetrier and Deville,[26] who have been able to report the history of a case treated twenty years ago, presents the greatest interest in permitting an estimate of the value of the treatment.

In this group of improved patients we can see that the duration of the evolution of the syringomyelia before the employment of roentgentherapy has been relatively short. Yet we may call attention to a few exceptions: In Case II the evolution seems to date back twelve years, but already, eight years after the appearance of the initial disturbances, the patient had been submitted to a radiation treatment for involvement of the lower limbs which had resulted in improvement persisting until the renewal of the treatment undertaken for a new involvement of the right arm of twelve months' duration, and treated with success. (2) In Case VIII it is true that the first involvement dated back sixteen years; treated then by radiation it was only after fourteen years that the improvement secured gave place to a new access which fortunately was very quickly controlled by roentgentherapy. (3) Case IX offers a history of the same sort. The evolution dated over twenty-one years. Six years after the commencement of the disease, efficient *x*-ray treatment of the lesion of the lower limbs (under the control of Dr. Babinski) was followed by a lasting clinical cure; then recurrence at the level of the right arm of only three months' duration before successful treatment with the rays was resumed.

If we review these facts we can say, in agreement with numerous authors who have been interested in this problem, that "in all cases where the sensory-motor disturbances have appeared in early adult life (as is the rule with congenital syringomyelia), *x*-ray treatment, if begun soon enough, can be expected to arrest the disease."

On the contrary, if the delay following the onset of the disease exceeds ten years, the prospects of success are very much reduced. But it is precisely in these cases of long-standing syringomyelia, often of late onset and atypical development rendering the diagnosis especially difficult and the prognosis bad, that one should not hesitate to resort to the only therapeutic means which seems to offer any chance of success.

And this all the more because roentgentherapy in no way contraindicates the use of the auxiliary electrical treatments which may be employed with advantage against the motor and trophic disturbances, such as continuous current, the excitomotor current or diathermy.

We should not forget that these treatments demand the greatest prudence by reason of the risk of producing burns in the areas of thermoanalgesia since the patients themselves cannot recognize the menace.

TECHNIC

We use systematically the following roentgentherapeutic technic: Spark-gap 25 cm.; intensity 2 ma.; filtration 5 mm. Al; focus-skin distance 30 cm.; elongated fields on each side of the spine, centering on the medullary canal.

This technic corresponds to the recommendation of Béclère[37] to utilize "penetrating but not deep radiotherapy" which seems to protect from the edematous congestion on one hand and, on the other, the aggravation of symptoms. While, in our personal experience, this plan has always given satisfaction, it is not less true that it has not been adopted by all authors; thus Keijser, Heinismann, Czerny, Proust, Mallet and Coliez, and Coliez and Rebuffel[36] in some recent publications have praised the use of penetrating roentgentherapy which has seemed to them susceptible of determining a more rapid regression of symptoms.

One will irradiate the region of the cord which corresponds to the topographical localization of the nervous symptoms; but it is highly important "to make sure that the treated zone considerably exceeds, both above and below, the site of the localization indicated by the nervous manifestations." We cannot over-emphasize this

point to which Claude has already drawn our attention; we know the existence of the medullary extensions of the lesion from the anatomical-pathological findings here reported. It is thus that in one of our cases, Case VII, it was only after very extensive irradiation over the segment higher than that indicated clinically that we were able to secure the arrest of the syringomyelic process and an obvious improvement.

From these facts, which confirm the frequency of the medullary prolongations of the glioma which we would have no reason at all for suspecting from the clinical symptoms, it has seemed to us almost logical to irradiate systematically the entire spinal cord from its origin to its terminal filaments, taking great care to utilize carefully marked ports of entry in order to avoid overlapping the irradiations.

It is always easy to mark out ports of irradiation by utilizing bony landmarks; or one may employ for this purpose the scheme of opaque cones, called the "spinal cord localizer," with its long axis parallel with the spine, divided obliquely in such a way that it is applied accurately on either side of the vertebral column.

What doses should be employed in an efficient treatment? This is a question not easily answered. A study of our tabulation shows sometimes a very considerable variation in the doses employed; only the progress of the case can guide us in our estimate of the useful dosage.

In a general way, we are partisans of moderate doses repeated at varying intervals according to the patients and the evolution of the affection; it is in this way that we decide upon series of 1200 to 1600 R per field. We use the cross-fire method, treating alternately from the right and from the left side of the spine in the course of each series, directing the normal ray obliquely toward the spinal canal. Each séance consists of a dose of 400 R, and we give two séances each week.

At the beginning of the treatment we space out the series over three to four weeks, and with this technic, which we prefer to that of massive doses given at longer intervals, the treatment may be continued without interruption over several months. And in proportion to the improvement of the patient and as the results become more marked and lasting, we permit a longer interval between the series; thus, certain of the patients, followed up for many years, have been able to receive without skin damage very large doses of *x*-rays (as high as 24,000 R and more).*

It is important to devote much care to the skin of these patients, for two reasons: the sometimes very prolonged duration of the treatment and the necessity of being able to repeat it at some time in the future. Through exercising prudence we have been permitted to follow some of our patients during many years, repeating the treatments at intervals as required without having had the slightest difficulty.

CONCLUSIONS

1. In brief, our statistics include 159 cases. Of these, 124 (about 79 per cent) have been improved to such a marked degree that in certain cases, small in number it is true, it has been justified to use the word cured. Thirty-three (about 21 per cent) have remained stationary, or have become aggravated.

2. The favorable percentage of our personal cases is somewhat lower than that of most previous reports (60 per cent instead of about 80 per cent).

3. We note, finally, that while in cases dating back more than five years roentgentherapy has achieved some little success, it is also in that group that failures are more frequent.

4. From this collection of facts one may then conclude that in the presence of an affection like syringomyelia, where the evolution of the malady is particularly severe, the use of roentgentherapy permits the hope that in an appreciable number of cases we shall see a considerable improve-

* It should be understood that all the doses we report as R units should be conidered as measured in French R units as defined by Solomon.

ment in the prognosis, but on condition that the *x*-rays shall be applied early, in young subjects, following absolutely the rule of treating an area much larger than that clinically involved, and following up the treatment for a long time.

5. Let us also remember how important it is to watch the skin and to take care of it as much as possible, and to protect from radiation those regions which later we may be called upon to treat.

6. We think, with Lhermitte, that a failure of roentgentherapy justifies one in supposing, within a certain limit, that a neoplastic process is not the causative lesion.

7. Even in the presence of a very old case, of many years' development, one cannot dare to neglect the only treatment which up to the present time has seemed able to deal with and oppose an obstacle to the progress of the disease.

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STRUCTURAL FACTORS IN STATIC DISORDERS OF THE FOOT*

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WITHIN the last year we have been favored with a very interesting and valuable article from Sir Arthur Keith, entitled "The History of the Human Foot and its Bearing on Orthopaedic Practice."[1] In it he implies the existence of two clinical schools of thought in regard to static foot disorders; or to be more exact, he recognizes the present existence of one school as having superseded the other which is now out of date, and seems to assign to me the uncertain honor of being to his knowledge, its single surviving advocate.

I shall not presume to use this occasion as an opportunity for arguing personal ideas, nor would I impose myself upon the courtesy of your esteemed society, were I not convinced that the conclusions which I hold are entertained by some of you at least and that their soundness is established by substantial evidence. Keith has given his support to one side, and I appreciate this privilege of submitting before you the results of studies which contribute to the opposing point of view.

Allow me to quote directly from his article.

> Thirty years ago it was not uncommon to meet with surgeons who regarded "flat-foot" as the collapse of a mechanical arch,—one which depended on the shape of bones, and strength of supporting ligaments. I thought this conception, a vitally wrong one for men in practice, would die with the generation which held it, but in this I find myself mistaken. My young friend, Dr. Dudley J. Morton, holds that "the term balance as applied to the foot structure does not refer to muscle activity, but to the arrangement of the bones and ligaments which furnishes a stable base upon which body-weight can be supported with the least demand for muscular exertion and propelled evenly balanced upon the lever axis . . . There is no need in Liverpool to insist that the longitudinal arch of the foot is dependent on properly and automatically balanced action of muscles in the leg and foot.

The swing from an earlier structural concept of the etiology of static foot disorder, to the later muscular concept, has been so strong that undoubtedly the latter has become the predominating school, not only in England, but also in this country and elsewhere. Its interpretation according to Keith's statement may, I believe, be fairly and briefly stated as follows:

Static foot disorders, especially as they involve the longitudinal arch, are primarily due to weakness of the muscles (supinator and flexor) of the leg and foot, or to a disproportion of strength between them and the opposing muscle groups.

Such an interpretation places the onus of foot disorder upon the muscles; if any bone or ligamentous defects are recognized, as indeed they must be in the more advanced cases, their recognition is so limited as to make one regard them merely as changes secondary to the original muscular fault. Hence, although the bone and ligamentous structures compose the actual weight-supporting framework of the foot, there is no provision within this concept for the possibility of a primary fault occurring in these structures. The concept seems to presuppose that the pattern and construction of this framework are 100 per cent mechanically perfect at the start, in all but obviously deformed feet.

In contrast, the interpretation which those of us who hold the opposing view maintain, recognizes a potentiality of disturbance in both structural and muscular elements of the foot, although we are

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inclined to consider the structural defects as the more frequent seat of primary fault. In the article from which Keith has quoted,[2] I attempted to identify and to differentiate very clearly structural balance and muscle balance. His quotation comprised my definition of the former, but he makes no reference to my discussion of the latter.

It seems needless to say that any concept of static foot disorder which does not include recognition of muscular disturbance also as a possible primary fault in a certain percentage of cases, could hardly lay claim in my opinion to serious consideration; for all organic tissues are liable to imperfection.

When my earlier article was written, the possibility of primary defects being located in the bone and ligamentous structures was appreciated, but at that time I was not able to give them specific identification. Subsequent studies have enabled me to recognize certain structural variations or characters which so affect the normal mechanism of the foot, that they can be classified as naught else than primary or causative factors of static foot disability.

Before describing these structural characters, however, may I be permitted to draw your attention to a serious weakness in the defensive position of the opposing concept.

The muscular explanation of foot disorder acquires its strength chiefly through its wide endorsement, for it is admittedly a widely accepted explanation. But among all the writings discussing foot trouble, and from all the foot examinations which we know have been undertaken by individuals and by organizations, there has not appeared to my knowledge a single table of statistics giving the relative strength of the muscles in normal and abnormal feet, by which concrete proof has been furnished to uphold the muscular concept. Does this apparent lack of proof represent a willingness to allow the popularity of a belief to constitute its verification? Or is it due to indisposition toward publishing results of examinations which were condemned because they did not conform to a premature conclusion? I do not wish to seem unfair in these questions but I do feel that there is a strange significance in this lack of published proof, and that I am entitled to remark upon it.

MATERIAL

The studies from which the present findings have been taken were begun at the New Haven Hospital (Yale University) where 100 metatarsalgic cases were collected for etiological analysis. Later its scope was extended to longitudinal arch disorder by including this type of disability, and also by examinations (clinical and by *x*-ray) of the feet of incoming student nurses of that institution. Subsequently the work was continued among the student nurses at the Presbyterian Hospital (Columbia University). Over 400 individuals are represented, about half of them being clinical cases, the other half comprising a group of young women whose feet are subject to severe occupational demands and who have been very advantageously available for observation.

The range of study covers not only established cases of static disability in various forms, but also observations of individuals before and after the actual occurrence of symptomatic disorder. It may not be out of place to state here that the disclosure by *x*-ray of the structural characters about to be described, has made it possible to identify among the student nurses those who were susceptible to foot trouble and who later developed symptoms under stress of their work.

STRUCTURAL FACTORS OF FOOT DISORDER

So far 3 structural characters have been identified which can be diagnosed by *x*-ray, and which specifically exert a vicious influence upon the mechanism of the foot. They are:

1. Laxity of the joint between the

inner cuneiform bones, and between them and the navicular bone.[3]

2. Shortness of the first metatarsal bone.[4]

3. Posteriorly located sesamoid bones below the head of the first metatarsal.

These 3 characters have been named in order of their estimated frequency and importance. They are found in a wide range of variation, from slight to conspicuous. Occasionally they occur as a single factor, but usually 2, or all 3 of them, presenting different degrees of fault, are found in combination.

A fourth character is an enlargement of the second metatarsal bone, particularly in its transverse diameter as seen in a dorsoplantar *x*-ray view of the foot. This character is of an entirely different nature, being an effect i.e., a normal physiological response to an increased burden thrown upon this bone. It is a constant, and consistent accompaniment to each of the 3 factors mentioned before. Greater age as well as the more exaggerated examples of the structural characters already listed, furnish the more notable degrees of this metatarsal hypertrophy.

The 3 causal characters, it will be noted, involve more or less directly the first metatarsal bone, and since this bone occupies a position common to both the front and mesial sides of the foot, any interference with its normal function must naturally affect the foot in both of these regions. They were first identified and their vicious effect upon the mechanism of the foot recognized, in the study of metatarsalgic cases, anterior foot trouble. Here their disturbing influence is so plainly demonstrable that it may be of advantage to consider this part of the foot first.

ANTERIOR FOOT TROUBLE

The Short First Metatarsal Bone (*Fig.* 1.): In a foot with a short (first) metatarsal bone, when body weight is carried forward and the heel raised, as in walking, the head of the second metatarsal becomes the chief fulcrum of the foot's leverage action because of its more advanced or distal position. Consequently instead of the stresses of body weight being evenly shared by the first metatarsal bone, they become heavily concentrated upon the second.

Fig. 1.

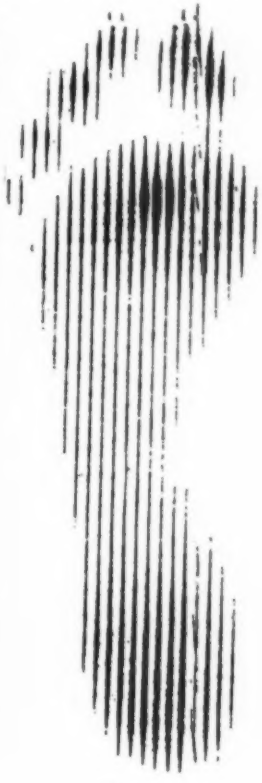

Fig. 2.

Fig. 1. Right foot of young adult female, showing shortness of first metatarsal bone as determined by relative positions of heads of first and second. Second metatarsal bone shows distinctly greater width than three outer metatarsals.

Fig. 2. Kinetographic imprint of foot shown in Figure 1. Heavy marking has registered concentration of pressure exerted upon head of second metatarsal bone as this individual walks.

This interpretation is clearly verified by a kinetographic print of the foot. (Fig. 2.) In this type of footprint, the relative amount of contact-pressure made by the heads of the metatarsal bones is registered by a corresponding heaviness of print as the person under examination walks or stands. The deeply printed area in the location of the head of the second metatarsal bone, has given an automatic

and unmistakable record of the concentration of body-weight placed upon that bone in this type of foot while walking. identical with that of a short first metatarsal. The kinetographic record presents the same major feature. (Fig. 5.)

Fig. 3.

Fig. 4.

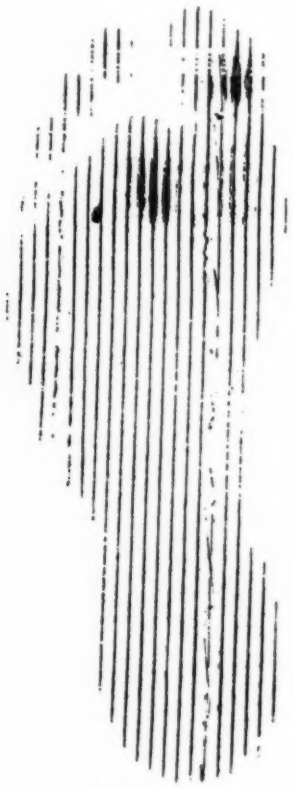

Fig. 5.

Fig. 3. Kinetographic imprint of normal and evenly balanced foot during act of walking. Observe even pressure distributed across entire ball of foot.

Fig. 4. Posteriorly located sesamoid bones. Transverse lines through these bones and through head of the second metatarsal represent relative position of center of weight-bearing contacts of first and second metatarsals. Effect upon mechanism of foot is similar to a short first metatarsal. Note increased stoutness of second metatarsal.

Fig. 5. Kinetographic imprint of same foot, showing same concentration of body-weight upon second metatarsal.

For comparison, the record of the action of a normal foot gives an evenly marked imprint across the entire width of the ball. (Fig. 3.)

Posteriorly-located Sesamoids: (Fig. 4.) The sesamoid bones lying below the head of the first metatarsal bone represent the position of the latter's bearing point upon the ground. Their position is relatively fixed because they are enclosed in the tendons of the short muscles. Consequently if their location as recorded by *x*-ray lies posteriorly to the position occupied by the head of the second metatarsal, the effect upon the foot's mechanism is practically

Accompanying Hypertrophy of the Second Metatarsal Bone: Since it can be demonstrated that in the two conditions just described, considerably more than a normal share of body weight is imposed upon the second metatarsal bone, its greater size in these cases may very reasonably and logically be regarded as a physiological hypertrophy. It combines a widening of the shaft and a thickening of the callous walls; but of these 2 types of reinforcing development, there seems to be no constant ratio, for their relative amounts differ in different cases.

This enlargement then, should be

regarded as a symptom rather than as a mere fortuitous condition; moreover, it has the quality of a keynote symptom, for it definitely reveals a disturbance in the normal distribution of weight-bearing within the anterior portion of the foot.

Hypermobility of the First Metatarsal Bone (Fig. 6.) This third character is recognized in *x*-ray examination by an unusual spacing or degree of separation between the inner and middle cuneiform bones. It is an extremely variable character. The combination of clinical and *x*-ray studies has demonstrated that this apparent separation of the 2 inner cuneiform bones is consistently significant of a laxity or hypermobility of the first metatarsal bone although actually, of the entire hallucal segment or inner pillar, of the foot. Associated with this hypermobility is a similar enlargement of the second metatarsal bone; consequently as might be forseen in the kinetographic print, a concentration of pressure is also registered by that bone in this type of foot. (Fig. 7.)

The mechanism of this defect differs, however, from that in the 2 formerly described conditions. In the present case, when body weight is placed on the foot, the plantar ligaments attached about the base of the second metatarsal and middle cuneiform bones become taut while there is still a certain amount of play in the ligaments attached to the basal portion of the first metatarsal and its cuneiform bone. Hence, the second metatarsal receives the concentration of body-weight, because the first metatarsal cannot accept its share until the slack in its plantar ligaments has been taken up, and the elimination of that slack occurs only if the foot rolls inward into a pronated posture.

Occurrence of Metatarsalgic Symptoms: At this point we may briefly consider the relation of these structural characters to the symptoms of metatarsalgia. Here the hypertrophy of the second metatarsal bone serves as a very effective guide, for with appreciation of the fact that its enlargement denotes a corresponding intensification of the stresses to which this bone is subject, we cannot avoid recognizing that its basal joints are at the same time

Fig. 6.

Fig. 7.

Fig. 6. *X*-ray view of foot with hypermobility of inner pillar (hallucal segment) indicated by distinct separation between inner and middle cuneiform bones resembling backward extension of first intermetatarsal space. Accompanying increased size of second metatarsal bone quite apparent.

Fig. 7. Kinetographic print of same foot. A distinct imprint of third metatarsal appears almost as strongly as second. Although foot presented notable, second degree pronated posture, imprint of first metatarsal much lighter than second and third.

subject to a similar intensification of strain. Under excessive or abusive use of the feet, the accumulated effects of function create a state of chronic traumatic irritation definitely localized in the region of the joint and plantar tissues lying posteriorly to the second metatarsal bone, causing a characteristic point of tenderness on palpation. (Fig. 8.) Owing to the close proximity of the internal plantar nerve and its local branches to this region (which now presents some degree of inflammatory congestion), the nerve in turn becomes affected and irritable. Continued use of the feet under

these conditions produces the subjective symptoms with which we are familiar, including the burning sensation of the soles

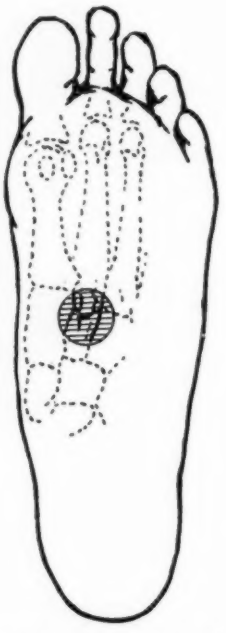

Fig. 8. Showing location of characteristic point of deep tenderness located under basal joint of second metatarsal bone due to chronic strain from concentration of body-weight upon that bone. (*J. Bone & Joint Surg.*)

and the formation of callosities as a result of the localized concentration of weight upon the second metatarsal bone.

THE LONGITUDINAL ARCH

Among the cases collected for study of the metatarsalgic disorder, a considerable number (approximately 20 per cent) of them, gave symptoms of strain of the longitudinal arch and presented a pronated posture of the feet. These and other cases of pronation were then studied clinically and by *x*-ray. As a result, a positive relationship between pronation deformity and hypermobility of the first metatarsal bone was disclosed in a way that could not be mistaken, and which demonstrated that this hypermobility was a prominent factor in these cases.

Analysis of the mechanics of the foot concurs with that finding. According to evidence obtained in studies on the evolutionary development of the human foot,[5] the functional axis is represented by a line drawn from the center of the heel forward to between the first and second toes. In normal function of the human foot, body weight is carried balanced upon that line. On the outer side of that functional axis, the 4 lateral metatarsal bones sustain this weight and act as a structural buttress to prevent loss of balance in that direction. On the inner side of that axis, the hallucal segment is the only structural safeguard to foot balance, and in order to be effective must be a firm and stable member.

In the condition referred to as hypermobility of the first metatarsal, the normal stability of this inner anterior pillar of the foot is impaired; for as explained above, when body weight is imposed upon a foot with this defect, a laxity or slack still persists in the ligaments attached to this inner pillar, while the plantar ligaments holding the outer metatarsal segments have become taut causing them to assume the burden of body weight. The inner pillar cannot become effective as a weight-supporting member until that slack in the ligaments is taken up; and this occurs only as the foot rolls into a position of pronation, upon which event we can all agree, the normal balance of the foot becomes affected or lost.

In a foot with such a hypermobile inner pillar, 1 of 2 things is likely to happen: (1) either it becomes overbalanced into a pronated position, whereby the slack in the plantar ligaments of the inner pillar is taken up and this member is made effective as a weight-supporting structure; or (2) the bowstring action of the supinating muscles and the pull of the flexors must be increased sufficiently to act as a substitute for the bony support that is lacking on the mesial side of the foot.

The mechanism of the foot's action in these alternate conditions is distinctly different, and certainly in neither of them can the mechanism be regarded as normal.

In the first alternative, the foot assumes a pronated posture; it has become un-

balanced with body weight concentrated upon the longitudinal arch, while upon the outer border of the foot, the burden is reduced correspondingly. The condition is vicious because it leads to a steadily progressive deformity and to painful disability. The other alternative imposes a definitely heightened and sustained muscular effort whereby body weight is lifted off the mesial border of the foot and transferred upon the 4 outer metatarsal bones. While by this procedure, a normal posture of the foot may be maintained, the substitution of muscular action to compensate for the structural defect, permits the slackness of the ligaments of the inner pillar to persist, so that although the first metatarsal may appear to have actual contact with the ground, it does not support body weight. As a matter of fact, however, the condition usually resolves itself into a combination of the 2 alternatives; some degree of pronation occurs when at the same time the action of the muscles becomes instinctively heightened to restrict the loss of foot balance. The result of this subconscious increase in muscle action apparently explains the prodromal symptoms of tiredness and aching of the feet so frequently observed in cases of pronation. These symptoms can admittedly be interpreted as due to muscular weakness; but a foot with normal strength of musculature acting under the mechanical disadvantage of such a structural defect, presents a disturbance in muscle balance that is conducive to exactly the same symptoms. The essential difference is causal; if a primary weakness actually lies in the muscles, they should be held responsible; but if some structural fault and not the muscles, furnishes the primary cause of disorder, then it is a shallow interpretation which confuses muscular weakness with an element of mechanical disadvantage under which the muscles act.

A notably short first metatarsal bone may also be associated with pronation deformity. In this case the fault may not be an accompanying ligamentous laxity at its base, but lie in the inability of the first metatarsal bone to give support because it cannot have strong contact with the ground owing to its shortness. But here again pronation will compensate for the defect and allow the first metatarsal to function, but only under the disadvantage of an unbalanced posture of the foot.

The question naturally arises as to what extent can we estimate the relative frequency of structural defects and of early muscular weakness as the original fault?

Clinical and *x*-ray studies of the feet of children give evidence that laxity of the first metatarsal bone is commonly present at a very early period, and that its presence in the adult foot is to be regarded as the persistence of an infantile condition. The short first metatarsal bone is evidently congenital. Consequently, there seems to be little chance to postulate any difference in the matter of temporal priority, since both muscular and structural factors may theoretically be carried back to an infantile or prenatal period.

Likewise, although the fibers which compose the ligaments are noted for their resistant, non-yielding quality, we know that ligaments as well as muscles are susceptable of stretching, through clinical observations and as demonstrated by contortionists on the stage and elsewhere. But, we have also seen well muscled, though loosely-jointed, individuals and persons who call themselves double-jointed because they can display an unusual degree of ligamentous laxity in certain joints. If that laxity in a healthy appearing individual should involve a non-weight-bearing joint, such as a very hyperextensible elbow, it would be quite acceptable to regard the condition as essentially ligamentous. Hence, if the laxity be located in the foot so that under body weight the foot assumes a faulty posture, is it not equally fair to believe that here also the fault may be essentially ligamentous? But here again, we are theorizing!

When we study the kinetographic records of pronated feet, however, tangible

evidence if furnished to designate structural fault as the dominating primary cause of longitudinal arch disorder.

Fig. 9. *X*-ray view of foot of middle-aged adult possessing all three of structural defects described: (a) short first metatarsal, (b) posteriorly located sesamoids, and (c, c,) inter-cuneiform mobility, with extraordinary hypertrophy of second metatarsal bone, showing greater width than even first metatarsal.

If pronation were essentially the result of muscular weakness with laxity of the first metatarsal bone occurring secondarily, the inward roll of the foot would show by heavy printing an exaggerated contact of the head of the first metatarsal bone under the concentration of body weight upon the inner border of the foot. Then if secondary stretching of the ligaments allowed for a stretching and lowering of the inner arch, the second and later the third metatarsal heads might show an increasingly heavy imprint; but that of the first would always dominate.

But the studies made have given a different result. Pronated feet have typically shown a concentration of pressure under the head of the second metatarsal which may extend to include the third; there is only a faint registration of the first metatarsal. With increased pronation deformity, there is a tendency for the first metatarsal to leave a stronger marking, but always the heaviest imprint is shown under the head of the second metatarsal. The light imprint of the first metatarsal in these cases allows of but one interpretation, i.e., the original presence of a structural fault, and one which directly affects the inner anterior pillar of the foot.

Relation of Structural Factors and Subjective Symptoms: It may seem paradoxical after discussing these structural characters and their harmful influence upon the foot's mechanism, for me to say that they are not of themselves an actual cause of symptoms, but comprise merely the potentiality of foot trouble. There must be a combination with other factors in order to have symptoms develop. The first of these is *function*. Obviously, a foot which is not subjected to the stresses of body weight will never be a seat of static disorder, although it may naturally suffer in other ways. Likewise, if the use of a foot possessing these defects is restricted, symptoms are not likely to occur; for the presence of these defects does not mean a total disability, but they represent a margin of lowered capability as compared with normal conditions. Hence, if functional demands are not carried beyond a certain point, the structural defects may never become an actual source of inconvenience or discomfort.

Another factor is *age*. Since the evidence indicates that these structural characters are traceable to the earliest periods of life, and since subjective symptoms other than postural (which are really objective) rarely occur before the approach of adulthood, usually later, there is a relatively long stretch of time when these defects are present but unattended by symptoms. The earliest appearance of symptoms seems to be coincident with the more rigid development of a matring fouot; so

it may be inferred that the greater elasticity and resiliency of youthful tissues serve to counteract the effect of structural faults toward producing symptoms throughout the earlier periods of life. The early half of adulthood when physical activity is most urgent and occupational demands heaviest, is the time when static foot disorder is most frequent.

But when we consider primitive and non-shoe-wearing peoples as practically free of such disorders, although they are equally liable as the populace of civilized areas to the structural foot defects that have been described, it is apparent that function and age are not sufficient of themselves to constitute the factors necessary for the usual production of symptoms. We must therefore recognize the functional factor in the light of (1) excessive function as imposed chiefly by economic and occupational requirements in our civilized mode of living, and (2) abusive function as function performed under unfavorable artificial conditions, such as poorly designed shoes, hard, level pavements and floors, etc. These artificial conditions do not affect normal feet to any appreciable degree, but they are vicious in their action upon structurally imperfect feet.

Under primitive conditions, the unclothed foot apparently retains youthful resiliency throughout its tissues for a much longer period; it is not ordinarily subjected to protracted periods of uninterrupted function; and the uneven surface of virgin ground induces a continuous shifting of weight stresses so that they are not constantly itensified upon any single part of the foot. In contrast, the conditions of civilization impose a more or less rigid and constricting covering of the foot too frequently attended with other harmful features; the feet are often subjected to prolonged hours of standing, or of work on the feet under the relentless urge of economic necessity; also, hard, smooth and level floors and pavements cause an inevitable uniformity and constancy in the concentration of body weight upon a defective mechanism causing a cumulative injury in a susceptible part, which has the effect of disabling the entire organ.

It is in these artificial elements therefore, that we find the supplemental factors whereby the structural defects of the feet become changed from a potential to an actual source of static disorder and disability.

COMMENTS

Probably no better analogue can be offered to indicate the relation of structural faults to painful symptoms in the feet, then by referring to the common defects of the eye. For with this organ we know that defects may exist even to a fairly marked degree without the individual being inconvenienced by them, or possibly being cognizant of their presence so long as his use of vision is causal and generalized. But let that individual become engaged in some line of work which imposes more constant and severe demands upon the use of his eyes, then it will not be long before symptoms of eye strain develop and accumulate, until he is forced to relinquish that work, or has to seek relief and correction from the ophthamologist. Here, as in the foot, the presence of defects originally acts merely to cut down the range of capability, for in both instances, symptoms developed only after the reduced limit of usefulness has been overstepped.

But the simile has a further application which should give us who are interested in feet, significant food for thought. We would laugh at the idea of submitting ourselves for correction in errors of refraction, to an "eye-man" who claimed that he could prescribe proper glasses merely by an external visual examination of the eyes without the use of any of the modern instruments by which such errors can be accurately and scientifically diagnosed and measured. Such an individual might well be assigned to a medieval period. And yet we have been content to depend

chiefly upon the same unreliable and unscientific visual method of examination as the only necessary basis for diagnosing and treating our foot cases. It is very rarely that such cases receive even an *x*-ray examination; and when this is made, it is usually done because we wish to learn if some other factor, such as arthritis, is complicating our problem, and not for any information which the film might be expected to furnish concerning the static trouble.

Our inability or reluctance to devise suitable instruments whereby static disorders of the feet can be scientifically recorded and studied is responsible for a situation which, if we will critically and conscientiously compare with the progressive and up-to-date methods employed by other branches of medicine, we will find to reflect very little credit in our direction. I do not mean that every orthopedic office should contain a room or two rooms filled with elaborate and expensive apparatus to be used for extensive and time-consuming examinations of what we are inclined to regard as a minor ailment. But I do mean that since we, as orthopedic surgeons regarded ourselves, and have the recognition of everyone else, as being the ultimate authority on such disorders, it is incumbent upon us as a group, to discard present primitive and inaccurate methods of handling these cases, and to develop through the efforts of our members who are especially interested in the problem some procedure which is modern and scientific and can be simplified sufficiently for practical use.

I believe that it can fairly be said that the prevailing method of visual examination of the feet, is as primitive a procedure as can be found anywhere within the range of medical practice. Against it, more criticism can be aimed at our group than against any other phase of our work and activities. Its crudeness and ineffectiveness are responsible for the fact that with the exception of only occasional contributions of merit, all the printed matter discussing static foot disorders is largely a rehashing of ideas held thirty, forty, and even fifty years ago.

It is responsible for numerous conflicting views among us (chiefly involving differences of opinion as to etiology and pathology) which represent a floundering effort to arrive at some true interpretation by theoretical surmise instead of by means of scientific data.

The inaccuracy and futility of this method of examination are demonstrated by the negligible scientific value which may be attached to the innumerable examinations of the feet that have been undertaken by individuals and organizations, and the little that has been contributed to our knowledge of foot disorders in comparison with the time and effort which have been expended on these examinations. It is true that many individuals may have profited physically from these examinations, but so have many headaches been helped by drug-store prescriptions. I do not deny the fact of merit but place a very low value upon the degree of merit.

To that same primitive procedure we can trace the almost complete lack of interest which the general practitioner displays toward foot troubles and his willingness to allow such cases to slip into the hands of the lay shoe and foot device dealer. He has been given no concrete knowledge, only hypothetical ideas of foot trouble to work upon, and as a rule his mind is as confused on foot troubles as that of the ordinary lay person. He is glad to avoid the responsibility of even the mildest type of cases and often refers them directly to the shoeman instead of to the orthopedic surgeon.

To naught else can we lay the responsibility for the encroachment of the shoe and foot device dealers and manufacturers on this field, bringing their foot experts who, after a three week's correspondence course and the filling out of a considerable number of bills-of-sale, usurp the position of authorities on foot trouble and do not hesitate to

match their precocious advice against that of any absent orthopedic surgeon. The financial success of these commercial organizations does not in my opinion, signify the merit of their products, but demonstrates to us where we have failed. Too often their enterprise is prompted by the lucrativeness of their market rather than by a desire to give physical benefits to their customers. We need not refute the altruistic sincerity of all such manufacturers and dealers, but in how many cases will we find that their product is backed by a really intelligent and scientific endeavor to understand the disorders they presume to treat? How many of them can show the facilities and personnel which such study would require? In spite of elaborate and stereotyped advertising propaganda, their goods are little better than a therapeutic hunch and usually comprise only some slight modification of ordinary and conventional devices or patterns. Nevertheless the shoeman could hold the same highly respected and necessary position to the orthopedic surgeons and medical profession, as we observe in the relation of the optician to the ophthamologist; but this will never happen until the orthopedic surgeon places his work on the foot, upon some modern standard comparable with that attained by the ophthalmologist in his field of work.

Finally, it has allowed mistaken concepts to persist which have little more than their traditional quality to uphold them. Conspicuous in this is the idea of an anterior metatarsal arch, formed by the heads or anterior ends, of the metatarsal bones. There is no such arch or arched conformation, in this particular region of the foot, for each bone has direct contact with the ground through the intervening tissues. The idea implies what amounts to a physical impossibility, for since the heads of these bones are separated from each other, the only structure that might induce that conformation is the weak transverse head of the adductor hallucis muscle which is hardly bigger than the risorius muscle of the face. Consequently we can well dispense with the diagnostic entity fallen anterior arches for, since there is no arch to begin with, there can be no depression of that arch to end with! Anterior foot trouble is not a morphological change in the position of the heads of these bones, for that is essentially determined by the contour of the supporting surface; but as I have attempted to show, the disorder is an improper distribution of bodyweight upon the metatarsal bones, and this is conditioned chiefly by ligamentous and bony factors.

It may have been noted that no attention has been given to the exaggerated flat foot condition; this has been avoided for the same reason that when the etiology and its bearing upon the pathology of typhoid fever or any other disease are discussed, the moribund or incurable case is not considered relevant to the subject. It is upon the causal factors and their action whereby the individual is changed from a state of health to one of disease, that attention is naturally centered; thus in the present instance, our discussion has properly been limited to causal factors and the early stages of disorder.

Static disorders of the feet are not spectacular. Objectively they present a dreary and monotonous variety in degrees of deformity with or without symptoms, so that in comparison with more acute and outstanding ailments, they give much less incentive for the same earnest analytical study. Within the scope of the muscular faults, a shortness of the heel cord or calf muscles stands out as the single, and the only specific and demonstrable source of disorder. With this one exception, we seem to have been satisfied with generalizations and surmise. But if we are rightfully to maintain ourselves as authorities of this type of ailment, it is due equally to ourselves and to the public who really invest us with that authority, that we show our dissatisfaction with generalizations and turn our attention toward seeking out what is specific and definite. In this effort,

I believe that greatest advantage will lie with those who recognize the structural framework of the foot as the principal seat of primary faults.

The structural defects that have been described in this paper have been definitely identified, and their influence upon the mechanism of the foot analysed. Continuation of such work is necessary in order to give them exact and proper valuation. More factors will surely be recognized as the interest of others becomes more actively engaged in this phase of the problem. And I am satisfied that the present contribution will have served a useful purpose if it disturbs the complacent idea that muscular weakness is a sufficient explanation of these disorders, and prompts diligent search for more definite knowledge.

Always it must be remembered however, that external factors are of equal importance in producing symptoms as factors contained within the foot; static foot disorder is essentially the supplementary action of both, and this should constantly be borne in mind not only in the study but also in the treatment of every case.

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DISCUSSION

Dr. Mather Cleveland: The importance of foot disorders cannot be overestimated. When we consider the large number of draft rejections for this condition during the late war, we are brought face to face with a major problem.

A large proportion of our practice in dispensary and office is related to foot trouble. The very term orthopedic, properly or improperly spelled, suggests to the layman a foot doctor, and if we are to be so considered we should welcome just such a paper as that presented tonight.

I agree heartily with Dr. Morton that foot ailments are exploited very profitably by shoe salesmen, podiatrists, and countless others ill prepared by insufficient or no training to diagnose and treat these conditions.

Dr. Morton has stressed the controversy between proponents of the muscular concept of these static disorders and those adhering to the structural concept. I must say that when one observes the effect of a disease, such an infantile paralysis, in the foot where the musculature is weakened or destroyed and as a result the foot goes into valgus or varus, as the case may be, the rôle of an intact musculature in maintaining a properly balanced foot cannot be disregarded.

In a large number of food disorders due to contracted tendo Achillis, where the limit of dorsal flexion is from 90° to 100°, we see the calf, which is normally five times as strong as the anterior tibial group, exerting a much greater pull proportionately. Such an individual bears more weight on his forefoot, and in consequence develops painful callosities below the metatarsal heads. In an effort to stabilize this foot, it is usually everted and begins to pronate. These patients have cramps in the calves of their legs, often turn their ankles, and have pain below the longitudinal arch and the forefoot. I cite this large group of foot disorders as an instance of the influence of the musculature on the foot.

The first metatarsal is always described as the shortest and thickest of the metatarsals. I should like to ask Dr. Morton when he considers a first metatarsal abnormally short.

The laxity of the joints on the medial side of the foot has been recognized as a factor in pronated feet. Dr. Morton apparently considers it a cause of this condition. A number of surgical procedures have been suggested to stabilize these joints by fusion along the medial border from the astragalus to the first metatarsal.

The sesamoids are originally dumb-bell shape, with the long flexor to the toe running over the intervening bar. In man, there is only a fibrous sling between the two expanded portions, they are ossicles in the tendons of the intrinsic muscles which produce flexion at

the metacarpophalangeal joint. Each of these sesamoids has a small capsule and joint surface connecting it to the overlying metatarsal head. They are subject to injuries, (fractures, contusions, etc.) the bursa frequently becoming inflamed, the painful sesamoid a real clinical condition to be relieved by surgical removal. My impression is that the sesamoid has a moderate amount of motion and its position is therefore variable.

I am glad to hear Dr. Morton dismiss the theory of an anterior arch, which we use so loosely. The metatarsal arch, as such, is formed by the base of the metatarsal bones; the heads of these bones, in a weight-bearing foot, are on the ground. Dr. Morton has elsewhere shown that the normal line of weight-bearing lies between the first and second metatarsal heads.

The deviation from this normal with a shift to the outer side of the foot, causing increased weight on the second and third metatarsal heads, causes the symptoms we describe as metatarsalgia with a rounded forefoot, convex inferiorly, with painful calluses below the heads of metatarsals one and two.

Dr. Morton has emphasized the importance of the kinetograph in the diagnosis of these foot disorders. I hope he will speak briefly of the practical application of the latter for the clinician. Instruments such as these, as diagnostic aids, however, are a two-edged sword. I recall a description, written in 1820 by Abernethy, of a simple crack fracture without deformity. His observations were infinitely more thorough than those we make, relying as we do largely on the roentgenograms. No machine can excuse us from a full and intelligent use of our eyes and fingers.

Many of us see children with weak feet, due, perhaps, to these structural defects which have been described. Are exercises of any avail in these feet? I should gather from Dr. Morton's observations that there is not much use in teaching these children to shift their body weight to the outer border of the foot because it further aggravates the weakness of the inner pillar of the longitudinal arch. However, some children do it without being taught; they are the ones with weak feet who toe-in markedly to shift the weight off the medial border of the feet. I must say that I have often been disappointed in watching for any marked improvement in some children's feet with exercises. Such cases may well be due to structural defects.

I should like to ask Dr. Morton if he is ready to suggest any line of treatment for the cases he has described.

Dr. E. D. Oppenheimer: We come into the world with a certain anatomy, and I believe the anatomy we have when we grow up was there when we were infants, only not so well developed. Our feet are inherited from our ancestors, certainly from our grandfathers, and when a child has so-called flat feet I do not hesitate to say that it is the grandfather's fault. I question whether the structure was the cause of the disability. We are given these lower extremities, but we do with them what we choose. We are trying to get away with a new function on an old anatomy. When we come to a criticism of what is right we must say for what purpose. The short heel cord is the only thing we add to the foot.

Dr. Morton has evidently shown the feet of young ladies. Every one failed to show in the graph heel-weight. They all carry the weight on their toes. If they had their shoes on there would have been a different mechanism; but they have been trained to this since childhood. We have used the limbs that nature has given us, and have attempted to work it out that way. That is our fault. To examine savages and then say what should be the normal foot will not help. I know that no savage can stand fourteen hours behind a counter day after day without trouble. That is what the young girls are doing, and some have no foot complaint. Foot disability is a functional condition in over 85 per cent of the cases. Some people overburden their feet. There must be a limit to everything, but we cannot say what structure or arrangement of the bones will account for that difficulty.

As for the problem, we must face it empirically, and do what we can for the people with the structure they have inherited. One further point: In figuring out the stress on the foot, we must figure it the way it is used; whether the foot is rotated in or out makes an enormous difference.

Dr. Arthur H. Cilley: As usual, I don't agree with anybody. The article was altogether too scientific for me to follow, and I don't know anything about the anatomical factors which Dr. Morton has spoken of, except very roughly.

He did not say anything about treatment. It seems to me that in our work on feet the

fault we fall into is primarily the treatment, in that we treat the wrong end of the anatomy. We consider the disabled foot as the cause of the condition, and I personally believe that people get well above their shoulders and not below the knees. They have to learn to use their machine in the way that will carry on the work we are putting our feet to. I don't think there is any question that our feet were not made to do the work we are compelling them to do, to wear the God-forsaken shoes we do and stand or walk all day on nothing that has more spring to it than a rug which we are afraid will slip if we step on it.

I was glad to hear Dr. Morton mention over again the fact that in walking the heads of the metatarsals all come to the ground, that the middle ones do not stand up in the air. It is amusing to see diagrams on the board which purport to show an anterior metatarsal arch. The section which shows the arch is wrong because it goes through the head of the first and perhaps the head of the fifth metatarsal, but does not strike the head of any other metatarsal; it cuts through the other necks which are not supposed to strike the ground, and consequently gives an appearance of an arch which is not present.

I don't believe that the short heel cord is the cause of foot trouble; I believe it is the result. If I believed it was the cause, I should expect to find it in children with weak abducted feet. I have been looking for such a foot for years and don't find it in children, but it is very commonly found in adults; and I believe that when present it is of importance, but I have seen many weak painful feet without it.

The difficulty I find in the anatomical discussion and muscle discussion is that I think both are elements; but I think the chief disability is in the controlling mechanism, which is above the shoulders. I wish to say again that I am sufficient of a mossback to have been unable to improve materially on Dr. Royal Whitman, and I still believe that he knows a great deal about the foot, and that he knows a darn sight more about the foot than the men who differ from him.

Dr. Morton, *closing:* I have not attempted to discuss treatment in this paper. What I have wanted to do was to urge you who are interested in foot problems to avoid conclusions based upon generalizations and interpretations supported only by visual examinations. Truly scientific interpretations can best be drawn from data which are obtained automatically and mechanically, and which yield the least chance of the personality of the examiner being involved. I have referred to the instruments used in the diagnosis and treatment of eye defects, because they illustrate the mechanical element which is so completely lacking in our method of examination for static foot disorder.

I do not mean to imply that the same mathematical accuracy as is required in the care of eye disorders should apply to foot ailments, and particularly in their treatment. It is the need for some method of identifying and recording foot defects by approved mechanical means that I would emphasize. It is only by such means that we can break away from our traditional and theoretical interpretations of foot troubles and the confusion of conflicting personal ideas in order to replace them with sound and scientific knowledge whereby both diagnosis and treatment can be brought to a higher and scientifically sound standard.

The three structural defects of the foot which I have pointed out to you tonight, are distinct morphological entities that can be disclosed and identified by mechanical means. Their vicious effects upon the foot's mechanism are clearly discernible; hence they constitute definite factors in the pathology of static ailments of the feet. They do not comprise the whole story; nevertheless in their recognition we can, I believe, find justification for reviewing the entire problem in order to gain a clearer knowledge and valuation of both structural and functional factors.

NEW INSTRUMENTS

A NEW CYSTOSCOPIC RONGEUR*

THOMAS J. KIRWIN, M.D.

NEW YORK CITY

SO many cystoscopic instruments are now on the market that it would seem to require some temerity to add another to the list. But it may be argued that the very fact that special devices for use in cystoscopic work are so numerous, indicates rather pointedly that no one of them is absolutely perfect. There are probably few practicing urologists who have not, at one time or another, found themselves in a situation where no single instrument in their possession would suit the exigencies of the case in hand. And most of those so situated have, I am sure, then and there registered a vow that as soon as they could get time they would fix up something that would take care of that special situation.

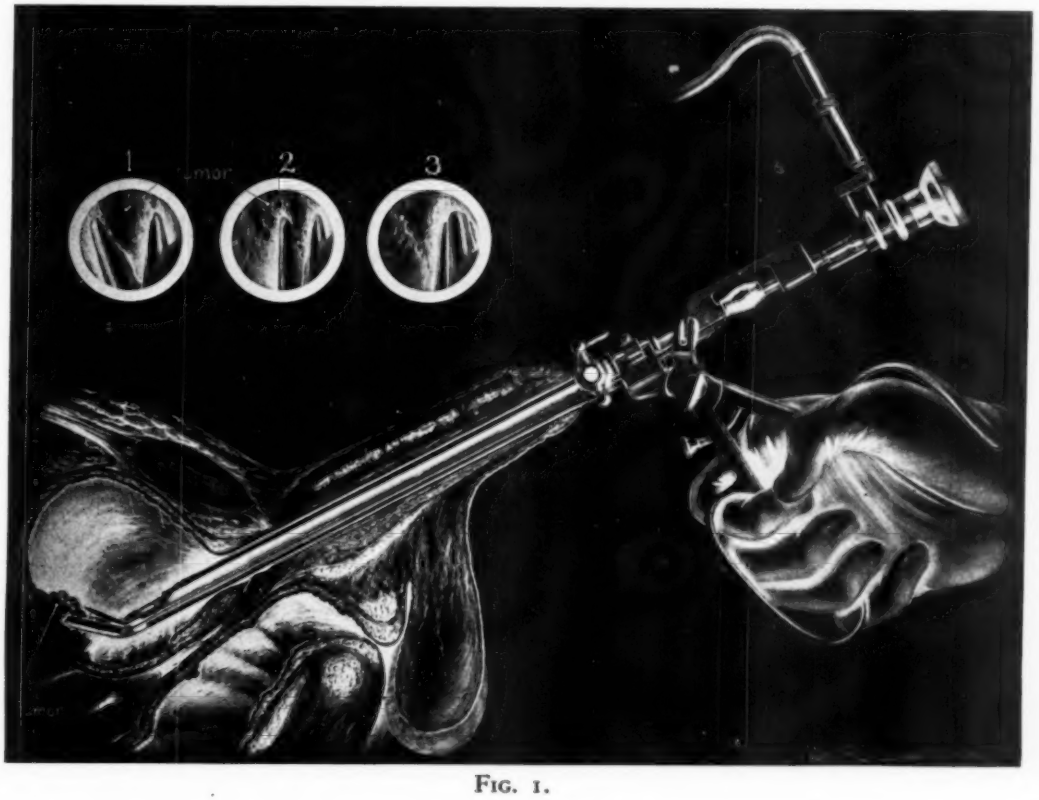

FIG. 1.

Nitze's ingenuity did not stop with the designing of the cystoscope itself. As soon as he had perfected it sufficiently to make it practical for regular use, the need of instruments particularly designed to use through it became urgent. He therefore, set himself to work to meet this demand. One of the most crying needs was for something to seize upon and, if need be, crush stones within the bladder. To fill this need the cystoscopic rongeur we have today first came into being. Casper in

*Submitted for publication July 15, 1930.

Germany, Luys in France, and Young and a number of others in our own country, have all been concerned in the perfecting of this most useful cystoscopic accessory. Young's rongeur seems to be the one most generally used. Although introduced some time ago (1910) it has never been displaced by such later designs as that of Lowsley, adapted to McCarthy's operating cystoscope. It seems presumptuous to put forward still another instrument designed for the same purpose, yet it has served me better than any of those just mentioned, having all of their advantages and also embodying some that are peculiar to itself. As its blade and grasping jaw are always in the direct line of vision, no matter what angle one may be obliged to search, the operator can always see exactly what he is doing. Moreover, mechanically it is much stronger than any cystoscopic rongeur now available. Only those who have had fragile instruments fail them in time of great need can fully appreciate this second advantage.

This instrument may be described as an irrigating rongeur. With the make-up of a cystoscope having facilities for illumination and irrigation, it combines the McCarthy fore-oblique telescope affording direct vision of any portion of the bladder, and a rongeur of exceptional mechanical strength, fitted to deal with any tumor mass likely to occur in the bladder, or to remove any tissue cleanly and expeditiously. Both rongeur jaws are curved, one being fixed. The movable jaw is controlled by a two-jointed rod connected with a pistol-grip handle. Because of the powerful leverage upon which the movement is calculated, the bite of the rongeur is stronger than in any instrument previously designed. The telescope is so arranged that the jaws of the rongeur are always in the direct line of vision no matter what part of the bladder is being explored. The telescope is removable to permit more extensive irrigation if desired. The irrigation system provides facilities for keeping the distending fluid clear at all times. Provision is made for sliding the lamp and objective toward the jaws of the rongeur, according to the location of the operative field.

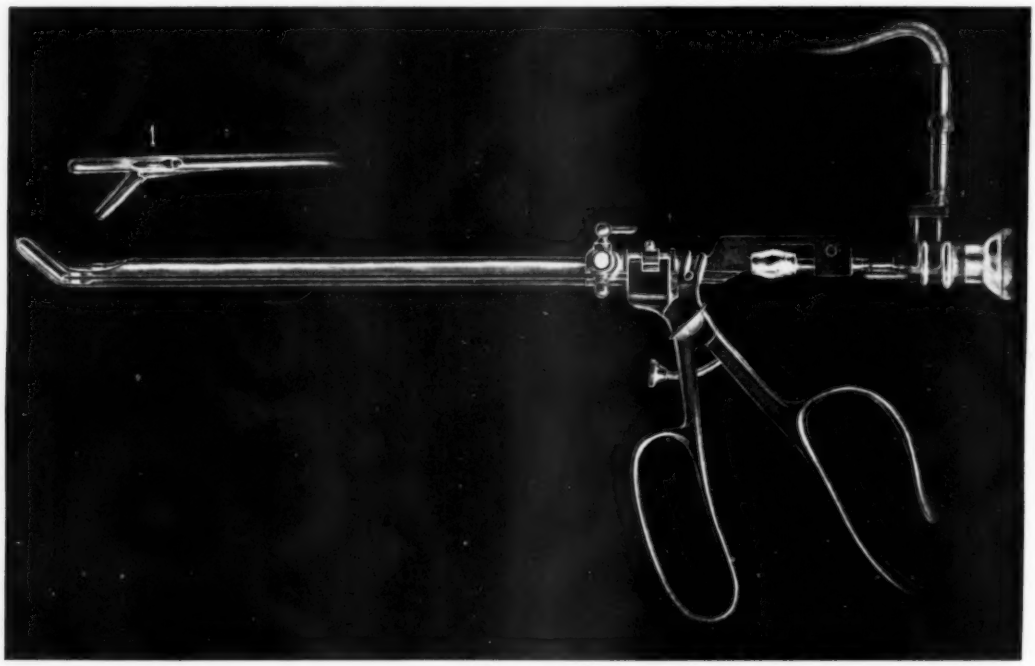

Fig. 2.

CASE REPORTS

CASE REPORTS BY DR. ARTHUR KRIDA

NEW YORK

TENDON TRANSPLANTATION FOR IRREPARABLE MUSCULOSPIRAL INJURY*

THE disability which follows section of the musculospiral nerve just above the level of the elbow is paralysis of the supinator longus and brevis, of all the extensors of the wrist, fingers and thumb. There is wrist, finger and thumb drop, with preservation of all the flexor mechanism. The sensory loss on the back of the hand is unimportant and is usually, as a matter of fact, compensated for by concentric substitution by ingrowth from neighboring cutaneous nerves.

In this case the nerve was explored fourteen months after injury. Due to the extent and location of the injury, no suture was possible. Tendon transplantation was done at a secondary operation, with the result shown.

H. S., aged seventeen, male. Hospital Ruptured and Crippled, Oct. 17, 1927.

Fourteen months previously sustained a deep laceration just above the bend of right elbow. There was immediate paralysis of the muscles supplied by the musculospiral nerve. Through and through drainage was established and the wound healed up promptly.

On examination at the time of his admission to the Hospital for the Ruptured and Crippled, he presented a paralysis of the supinator longus and brevis, of the extensor carpi radialis longior and brevior, of the extensor communis and of the three extensors of the thumb. The extensor carpi ulnaris was weak but active, and in addition to the wrist, finger and thumb drop, he had a certain amount of ulnar deviation due to the persistence of the latter muscle. There was a very much restricted area of sensory loss at the base of the index finger on the dorsum. There were no contractures.

Operation 1, October 17, 1927. The musculospiral nerve was explored through a curved lateral incision. The nerve was approached from above, and was found to terminate in an elongated bulb about 1¾ in. in length. The bulb terminated in a mass of scar tissue which was intimately adherent to the underlying condyle.

The bulb was excised. The nerve was progressively sectioned above the bulb, and not for 2 in. above it was an even passably satisfactory nerve section encountered. There was no possibility of suture in this area, and the incision was closed.

Operation 2. November 14, 1927. Jones operation. A long J-shaped incision was made on the dorsum of the forearm, the lower "J" end being just above the wrist. The point of insertion of the pronator radii teres was identified. The extensor carpi radialis brevior, the extensor communis, and the three thumb extensors were identified.

A midline incision of the front aspect of the lower forearm was then made. The tendons of the flexor carpi radialis and ulnaris were identified.

Transplantation A. The tendon of the pronator radii teres was separated from the radius and transplanted into the extensor carpi radialis brevior.

Transplantation B. The flexor carpi radialis was separated at its insertion, passed around to the dorsum through a subcutaneous tunnel, and transplanted into the three thumb extensors.

Transplantation C. The flexor carpi ulnaris was similarly transplanted into the tendons of the extensor communis digitorum.

The incisions were closed with silk. A splint holding the wrist, fingers and thumb in hypepextension was applied.

He was discharged thirty-three days after operation. At the end of his hospital stay all the transplants were active but weak. During his hospital stay, I removed his splint on alternate days and manipulated his fingers, in order to preserve, as far as possible, their flexibility. From the tenth day he was instructed in activating the transplants. He was discharged, wearing his splint, with instruction to discard the same as soon as all the transplanted tendons were acting well.

* Presented at the Medical Society, New York University, February, 1930.

He discarded his splint four weeks later. Since that time, he has worked at various jobs, and has for some time been working at a soda fountain. Two years and three months after operation, his hand is very strong and useful. His range of dorsal flexion of the wrist, fingers and thumb is complete, and is accomplished by the transplanted tendons.

It may be noted that the biceps humeri now acts as the sole supinator, and performs this function perfectly satisfactorily.

Fig. 1. Range of extension of fingers and wrist obtained by tendon transplantation.

Fig. 2. Range of abduction of the thumb.

DISABILITY OF THE HAND*

Case 1. The patient, a business man aged forty-two, in good condition, about two and a half years ago came to the clinic of the Hospital for the Ruptured and Crippled, presenting a small, slightly painful lump in the palm of the right hand at the base of the fourth finger. It was evidently a small cyst of the tendon sheath. It could not be ruptured by forcible compression. He was therefore advised to have it operated upon at that time, but declined, and then had a course of physiotherapy treatment which did not change the situation. He eventually discontinued treatment. A year and a half later he returned having had a great deal of advice and treatment in the interim. He now had a swelling on the ulnar side of the hand extending up the forearm, and whenever he flexed his fingers he experienced pain and heard a coarse grating sound. The examination showed a swelling corresponding to the hypothenar eminence and the lower portion of the forearm. Flexion of the fingers was accompanied by a coarse grating and the mass in the hand would move into the forearm. There was no increase in the local temperature and but little infiltration. The diagnosis was a chronic tenosy noviti of the tendon sheaths of the flexor tendons.

At operation seven months ago the diseased area was exposed by a longitudinal incision. Finding at the operation was a chronic hyperplastic thickening of the sheaths of the flexor tendons of the fingers extending up to 2.5 in. above the wrist. This was divided into two parts, a mass below and a mass above the anterior ligament of the wrist joint. On opening into the lower mass it was found to be filled with two teaspoonfuls of homogeneous perfectly smooth oval rice bodies about ⅛ in. in diameter. On flexing the fingers, this mass of rice bodies would pass between the anterior ligament up into the tendon sheaths of the forearm.

The dissection consisted of the removal of all the tissue that seemed inflamed and thickened, the tendons themselves being only slightly involved in the process.

The microscopic examination of the tissue showed it to be chronic hyperplastic tissue without evidence of tuberculosis.

He has made a perfect recovery of function and is relieved of the pain of which he formerly complained.

Case 11. The second patient is a marine engineer, thirty-two years of age. He was first seen five and one half years ago. His history was that a few months previously, while in a Syrian port he was attacked by a native with a long knife, who inflicted a long cut on the inner side of his arm and forearm. He was taken to a local hospital and operated upon. The operation was reported to have included suture

* Read before the Section of Orthopedic Surgery, New York Academy of Medicine, December 30, 1929.

of the ulnar and median nerves. However, gas infection set in and he was very sick for some weeks.

When he came to this country three or four months later he presented a very long scar on the inner side, extending nearly from the axilla to the wrist. The clinical picture was that of a complete severance of the median and ulnar nerves high in the arm. The only muscles that were active were those supplied by the musculospiral nerve. The hand was totally useless functionally, in addition to the hazard of injury by reason of the anesthesia in the median and ulnar distribution.

The first operation consisted of a long incision corresponding in length to his scar. It was found that the ulnar nerve was severely scarred in the middle of the forearm. The median nerve at the point where it divided into its component branches was entirely destroyed. The ulnar nerve was traced through 3 in. of very dense scar tissue, and this segment was excised. The cut ends were of poor quality. However, when the ends were approximated after flexing the elbow and wrist, suture was done. The median nerve was obviously damaged so that no recovery could be expected. The ulnar nerve, by reason of the tremendous scarring and rather unsatisfactory end to end suture, could be expected to function only as a sensory supply in future. Therefore it was decided to proceed to tendon transplantation.

The tendon transplantation was this: the extensor carpi ulnaris was transplated into the deep flexors of the three lesser fingers; the extensor carpi radialis longior was inserted into the flexors of the index finger and the long flexor of the thumb. These transplants functioned quite nicely in a few weeks. It was noted, however, that while he had good flexion in his fingers and the terminal phalanx of the thumb, he had no power of opposition of the thumb.

A third operation consisted in opening and splitting into two portions, the long flexor of the thumb in the thenar mass, leaving one at the original insertion and passing the other around the radial side of the first metacarpal bone, in order that it might in some measure act as an opponens of the thumb.

I have since discovered that this operation was described by Steindler. At that time it was unknown to me. Until tonight, I saw the patient last two and one half years ago, at which time quite satisfactory function was developing.

I mention his case as an example of the efficiency of these transplants in the presence of a complete median and ulnar paralysis. The patient says the feeling in his hand has returned. We must assume that the ulnar fibers grew down to supply the skin and that they finally grew into and supplied the part formerly occupied by the median. He has strong flexion movements of his fingers and thumb and good opposition movements. The hand is useful and he has a strong grasp.

DISCUSSION

Dr. S. L. Koch: I was much interested in hearing Dr. Krida say that the microscopic examination of the tissue removed from the first case showed no evidence of tuberculosis. I would think from the clinical picture that the condition was probably a tuberculous tenosynovitis.

Dr. Auchincloss: That Dr. Krida found rice bodies creates a fairly strong assumption that the inflammatory reaction was tuberculosis. We have no right, however, to definitely assume that the presence of rice bodies means tuberculosis, for they may be found in tendon sheaths and in adventitious bursae that are not tuberculosis at all. It has been my experience, however, in ulnar bursa chronic infections containing rice bodies that the bursa sac has been tuberculosis, but it certainly does not mean that this is necessarily so. The dissection for a complete removal of the ulnar bursa investing all of the flexor tendons except the thumb with its prolongation into the little finger is a very interesting one, and well worth while when it is tuberculous. The annular ligament of the wrist should be divided. This is best done by making an oblique incision through it for it leaves the attachments on either side intact and only the middle portion requires to be sutured. Each tendon should be dissected in turn and the greatest care should be taken to avoid cutting the branches of the ulnar nerve to the fingers. Sometimes the superficial palmar arch requires ligation; in fact it is easier to do the dissection if this be done, but the nerves should be spared. A good incision for dissection of the ulnar bursa is indicated in the diagram. The longitudinal

scars in this incision are broken in several places by carrying the incision along flexion creases and it is astonishing to see how difficult

Fig. 1. Diagram of hand to show the way a longitudinal linear scar can be avoided in making a dissection of the ulnar bursa through the use of flexion creases.

it is to see scars in the fingers and hands months or years afterwards if attention to this principle of using the flexion creases as much as possible is adhered to.

Dr. Leo Mayer: As for the second case, the result is so remarkable and so far in advance of any similar tendon transplantation of that type that it seems to me there must be another factor which has come into play: that in spite of what Dr. Krida has told of the difficulty of nerve suture, partial regeneration of the nerve has occurred. Examination of the patient would seem to support that view. Not only are the transplanted muscles working but in addition the contraction of the flexors themselves in the region just below the elbow can be felt. There is almost a complete return of sensation in the fingers, and I question whether that could be possible unless there was some regeneration from the median and ulnar nerves.

Dr. Krida, *closing:* In answer to Dr. Mayer, the only change which is now present, except for a general gain in strength and usefulness, is that the flexor carpi radialis is active. The branch to that muscle being placed most proximally, may have escaped injury. The matter of the regeneration of the skin area is another story. I have often seen the cutaneous area of supply of the musculospiral nerve recover entirely, knowing at the same time that the nerve had been previously explored and had been definitely sectioned across, so that there was no possibility of fibers of that nerve growing down to that area. It is possible that in such cases a certain amount of concentric substitution takes place; nerves grow in from adjacent sources of supply to take the place of the others. In this case such concentric substitution has been quite complete.

Dr. Armitage Whitman: I think an historical reference may be in order. While I may seem a little young to be dwelling upon history nevertheless it is encouraging to think that perhaps nowadays less time is required for its making.

When I was a house surgeon all injuries and infections of the hand received their primary treatment in the Accident Room at the hands of the second assistant surgical intern, with the exception that cut tendons were to be reported to the House Surgeon. At the same time anyone suffering from hemorrhoids was welcomed at the front door and operated on in the main operating room with full aseptic precautions. Two years before Dr. Kanavel's book had appeared. Its excellence had at once been perceived by Dr. Auchincloss, who began, I think with us as fourth-year students that painstaking instruction and work upon the hand for which he is so well known.

FOREIGN BODIES IN THE URETHRA*

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NEW YORK

FOUR years ago, on the Bellevue Urological Service, I attempted in the following manner the removal of a stone lodged about midway in the pendulous urethra. First, I passed an endoscopic tube down to the stone and tried grasping it with alligator forceps. But since the shortest diameter of the stone was larger than the diameter of the tube, nothing was accomplished. Grasping the stone without the tube was then tried. Several different types of forceps were employed, all to no avail. I then resorted to what was thought would be a certain method of extracting the stone, namely, a perineal external urethrotomy. Attempts to pull the stone backward by forceps introduced through the urethrotomy wound, attempts to push it out with a sound from behind, and likewise attempts to push with a sound in front and pull with forceps from behind were all absolutely unsuccessful. Finally a sort of urethral litholapaxy with forceps was tried and, this failing, it seemed the only procedure that remained was to cut down directly on the stone from the dorsal aspect. This was done and while the stone was readily enough removed, the patient has a urethral fistula to this day. Of course this is the very condition I had made such an effort to avoid. But his infrequent though regular visits to our return clinic have been semi-annual reminders that my effort though sincere, should perhaps have been redoubled.

With the idea that it might be of interest to compare notes on the technic of removal and end-results of foreign bodies in other cases on the Bellevue Service, I have reviewed our similar cases of the past decade. If a stone caught in the urethra may be classified as a foreign body, the total number of urethral foreign body cases during this period is 17.

There were 14 stones and 3 cases of other foreign bodies. The stones were located as follows: Posterior urethra 7; anterior urethra 7, of which 2 were in the terminal 2 cm. Five of the patients had stones elsewhere, 2 in the kidney, 1 in the ureter and 2 in the bladder.

The various procedures for the removal of the stones were:

External urethrotomy (perineal)—6 cases, on half of which an internal urethrotomy was also done.
External urethrotomy (in penile portion of urethra) directly over stone—3 cases.
(External urethrotomy, perineal and also directly over stone in penile urethra—1 case.)
Suprapubic cystotomy—1 case.
Meatotomy—2 cases.
Dilation of urethra—1 case.
Removal with forceps—1 case.

The stones varied in size from a small pea to a large olive.

End-Results: There were two postoperative deaths. One patient, fifty-four years old, presumably died of myocarditis, eighteen hours after external and internal urethrotomy had been performed under spinal anesthesia. However it should be noted that his intramuscular phenolsulphonephthalein output was 5 per cent in the first hour and 10 per cent in the second. The other patient, twenty-two years old, died three days after his operation of renal insufficiency. Under general anesthesia the stone, as big as a large olive, was removed from the prostatic urethra through a suprapubic cystotomy wound.

Of the remaining cases, all eventually healed except the one described at some length previously and also one other patient whose urethra was cut directly over the stone. The latter was still passing the greater part of his urine through a urethral fistula at the time of his discharge, one month after operation. All trace of

* Read before the Section of Genito-Urinary Surgery, of New York Academy of Medicine, January 15, 1930.

him was lost after he left the hospital. In this case, it is only fair to state that there had been three fistulous tracts at the site of the stone, all of which were included in the incision for the stone.

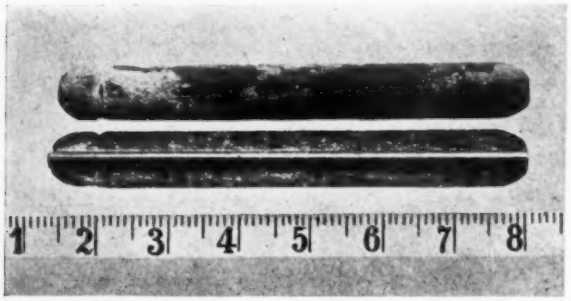

Fig. 1. Two halves of a portion of lead pencil showing lead intact in one of the halves. Note transverse shallow groove near left-hand end of pencil. (See footnote.)

Of the 3 cases of foreign body other than stone, one was that of a knotted rubber tube. This case was reported in detail by Dr. C. W. Collings before this section several years ago. The tube about the size of a 16 F. catheter contained three distinct knots, the knotted portion being in the posterior urethra with the end of the tube extending beyond the meatus for a distance of several inches. Traction on the tube resulted in nothing but pain. The tube was removed retrograde fashion by means of a perineal external urethrotomy.*

The second patient in this group presented a hat pin in the posterior two-thirds of the urethra. The point of the pin could be felt through the tissues at the penoscrotal angle. The pin was removed by perineal external urethrotomy. In both these cases the recovery was uneventful.

The third of the foreign body group, apart from the stone cases, is the one I have chosen to report in detail. I am reporting it chiefly because of the nature of the foreign body but also to illustrate with what comparative ease a sometimes difficult procedure may be turned into a simple one.

This patient, a nineteen year old boy, was sent to me with a note from his doctor to the effect that he had a stone caught in his urethra. After palpating the penis, I did not question his doctor's diagnosis. The foreign body, which was situated just a little anterior to the penoscrotal angle, could be grasped readily enough between the thumb and forefinger and it seemed to be immovable. There was quite a little induration around it. The mass by palpation measured approximately 1½ cm. transversely and possibly 2 cm. longitudinally.

The boy complained chiefly of passing a small stream when urinating, difficulty in urination and a pain in the perineum that greatly disturbed his night's rest.

Rectal digital examination and careful palpation of the perineum were negative. An attempt to pass a 12 F. olived-tipped silk catheter past the obstruction caused great pain and was unsuccessful.

The urine was cloudy and contained a fair amount of albumin, pus and a few red blood cells; non-protein nitrogen 37, creatinine 1.8.

X-rays and urethrograms showed a definite shadow, presumably that of a stone within the urethra. (Figs. 2 and 3.)

I had definitely made up my mind that a perineal external urethrotomy would be necessary for the removal of the foreign body and had hoped that cutting down on the urethra directly over it might be avoided.

On October 29, 1929, under spinal anesthesia, the foreign body was removed in the following manner:

An attempt to pass a whalebone filiform past the obstruction finally succeeded. With this as a guide a 14 F. tunnelled sound was then passed all the way to the bladder. Here I tried to grasp the stone with a pair of alligator forceps whose jaws were about 2 cm. long. As

* It is a strange coincidence that this patient was readmitted to the Bellevue Urological Service with another foreign body (on this occasion in his bladder) the day after this paper was read. Almost three years had elapsed since his previous sojourn as a result of the knotted tube. On this last occasion the foreign body was a portion of lead pencil, about 6½ cm. long. Near one end there was a shallow transverse groove, evidently for the purpose of attaching a string to the pencil. An *x*-ray disclosed a long, very narrow, shadow corresponding to the lead of the pencil. Cystoscopy showed that the pencil had separated into its two halves, the lead remaining wholly intact in one of the halves. (See Fig. 1.) Attempts to remove the fragments by means of the operating cystoscope were unavailing because of the difficulty of grasping the fragments in the cystoscopic forceps. Immediately a piece of the pencil was touched, ever so gently, it would float majestically out of reach.

Both fragments were finally removed through a suprapubic cystotomy incision under spinal anesthesia.

was expected, this proved to be difficult. The forceps would grasp the foreign body but on the slightest traction would slip off. Finally, just when it seemed useless to continue with this procedure, I obtained a satisfactory hold. Traction alone on the forceps availed nothing but traction plus a sort of milking procedure over the obstruction from without, finally did the trick. And then came a surprise. The supposed stone was not a stone at all but apparently a fragment of bone. A histological examination finally proved this. (Fig. 4.)

Fig. 2. Anteroposterior view of fragment of bone in urethra.

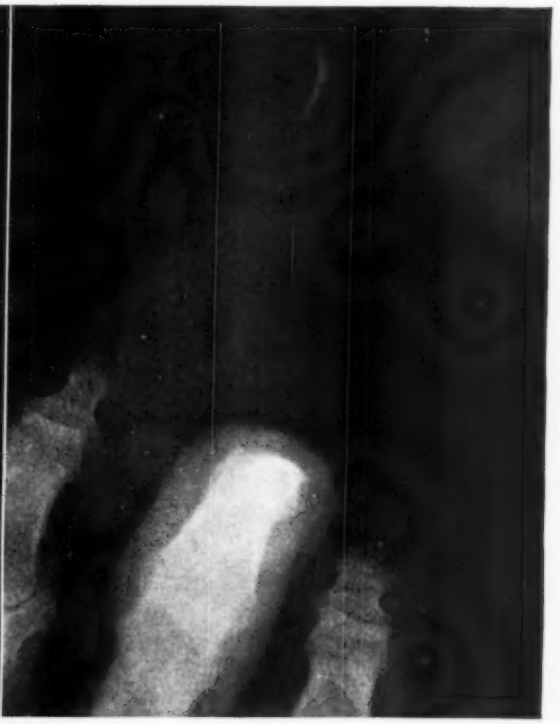

Fig. 3. Lateral view of fragment of bone in urethra.

A stricture at the site of the obstruction was cut to 30 F. by means of the Otis urethrotome and the operation was completed by passing a 29 F. sound to the bladder.

The patient's past history offers, in my opinion, the most plausible explanation of how the bone got there. In an automobile accident which occurred three years prior to his latest difficulty, he had sustained a rupture of the bladder and a fracture of the pelvis (chiefly of the ascending ramus of the pubis). The fragment of bone probably entered his bladder at the time of the accident or the operation, for the repair of his bladder, which soon followed. It is quite conceivable that, after his bladder healed, the fragment became wedged in the urethra during the act of urination.

Why the patient had complained of such intense perineal pain was quite a mystery to me until I received a recent communication from his doctor. The patient was discharged from the hospital on the fifth day postoperative, apparently feeling fine. About a week after returning home he developed a frank abscess which his doctor described a isschiorectal. This was drained and his troubles were apparently at an end.

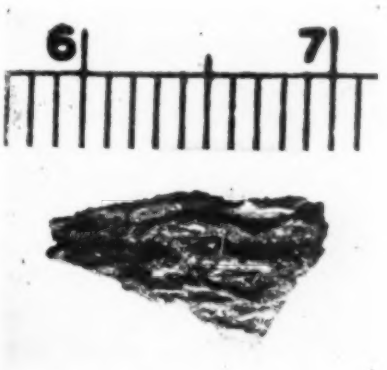

Fig. 4. Photograph of fragment of bone removed from urethra.

SUMMARY

1. Attention is called to the impropriety of opening the pendulous urethra directly over a foreign body.

2. An unusual foreign body of the urethra is described, a fragment of bone.

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EDITORIALS

PHYSIOTHERAPY IN RELATION TO SURGERY*

MANY years ago, while a student in the European Clinics, I became convinced of the value of physiotherapy as an adjunct in treatment in every department and specialty of medicine. In the great St. Georg Hospital in Hamburg I saw exemplified for the first time the water immersion treatment of burns and of all extensive open infected wounds. The patients were placed in large bathtubs in which water of an equable temperature was kept constantly circulating, and it was surprising to note the great benefit which these patients received from this type of treatment. In the large Clinics of Berlin, especially the first surgical clinic in which in 1912–1913 I happened to have been an assistant, and which was under the able supervision of Prof. August Bier, physical methods of treatment were greatly favored for chronic inflammatory lesions such as bone tuberculosis, osteomyelitis, etc. It was in this clinic that Prof. Klapp's methods of functional over-correction of scoliosis of the spine were first instituted. Daily I observed 100 to 150 young children going through exercises which, by muscular counter-pull, corrected vertebral deformities. It was in Bier's Clinic, as you know, that the principle of hyperemia as a therapeutic measure in the treatment of inflammatory and chronic affections of a part was first introduced. This method today does not receive the attention which it merits. From Prof. Bier's Clinic one could

*Read before the American College of Physical Therapy, Chicago, Nov. 5, 1929.

take a train to Vienna and enter the surgical clinics of Prof. Eiselsberg, and find that in 1912, he was sending most of his tuberculous affections to the clinics of Prof. Rollier in Switzerland, where the sun was curing the joints and bones of tuberculosis. In 1913 there were in Germany immense sanatoria for physical methods of therapy. A well-equipped model of its kind was the large sanatorium at Semmerung in the neighborhood of Vienna. In Berlin I noticed in the associated departments of the Virchow Krankenhaus and in the Moabit Hospital and the great Hospital at Haidenhain the remarkable corrective influence of physical methods of therapy, especially the influence which diathermia had upon chronic inflammatory lesions.

Impressed with the great interest that foreign clinicians had in physical methods of treatment in chronic diseases, and noting the improvement in their patients under these different methods, I naturally became convinced of the benefit derived from these therapeutic measures and decided to attempt to apply them, when possible, in the treatment of my own patients. In all the intervening years, from the time of my post graduate student days in Europe to the present time, never have I lost sight of, nor have I doubted the benefits to be derived from such treatment.

In 1914, we in this country were very backward in our application of physical therapeutic measures. However, this was not universal for well do I remember the great hall at the Massachusetts General Hospital where the Zander method of treatment of joint, bone and muscle defects was applied. When on my return from Europe I resumed the practice of surgery there was not in the city of Pittsburgh an accredited physician who limited himself to the practice of this division of therapeutics, and it is only recently that such specialists in treatment have separated themselves from the body of the profession.

Under these conditions I found it necessary in a very modest manner to apply diathermia in my practice. In 1914 I bought a high-frequency machine and found diathermia of value in chronic affections, especially those of bone and of joints and am still a faithful advocate of its use in these conditions. I have also noted the benefit to be derived from it in many chronic intra-abdominal lesions of a mild inflammatory type. My observation in the Army, where physiotherapy was given such acclaim and which produced such remarkable results, thoroughly convinced me of the efficacy of physical measures of treatment as adjuvants in surgical interventions. In 1926 I equipped, as an addition to my office, a physiotherapeutic laboratory. At the present time I have a nurse and an office assistant, two girls who are trained to apply various physical modalities. With the assistance of these two aides and a young physician who is in my office, we have fairly good results, and we are well pleased with the innovation which I have made. I do not solicit nor do I accept patients from other doctors for physical measures of treatment but confine such treatment to patients in my own practice and as helpful factors to other therapeutic measures.

In my discussion of this subject. I will treat only those phases of physiotherapy with which I am familiar. I am not familiar with the different hydrotherapeutic measures which I believe to be of great value in the treatment of disease but of which unfortunately I am not able to avail myself under the conditions that exist in my practice.

With the background that I have given, I shall now try to explain how and in what manner I have found physical measures of therapy of aid to me in surgical work. I shall first consider the patient who is to be operated upon. Irrespective of the character or the type of operation, it is the object of every surgeon to bring his patient to the operating table in the best possible physical and mental condition, so that he

may be resistant to a maximum degree to the shock and interference and physical disturbance which the operation entails. This is especially so in those who are weak and debilitated by a long period of severe illness. Such cases should be earnestly considered and should not be operated upon until conditions are favorable to them, or as favorable as is humanly possible.

We should not permit patients to be rushed into an operation when they are suffering from physical handicaps which can be corrected. Shallow, weak, anemic individuals should be taken in hand and treated by the proper method, so that they become stronger, more robust and healthier. Six weeks or more of treatment may be so conducted that their energy is revived and they are better fitted to endure the strain of an operation.

Thus if the operation is not imperative, patients should be placed in a suitable location and in environment where they will have a maximum of sunlight, good fresh air, quiet and rest. As it is not always possible to bring patients into ideal surroundings, it then behooves us to develop resistant processes in those who remain at home under our personal supervision. They should have their physical well-being developed to the highest possible degree. Of all the factors which produce improved tone, increase resistance, better mental reaction, none I believe has greater value than ultraviolet light, and I can recommend it most enthusiastically as a preliminary treatment for the weak and anemic on whom we consider it necessary to operate. In my hands ultraviolet both as a preoperative and postoperative measure of treatment has proved of great benefit. It acts both as a sedative and an energizing agent.

Rest, baths, massage are all of great value. Anemia should be corrected by methods which are available. If urgency demands, transfusion should be done. Colonic irrigation has proved of some benefit in cases where there is a low-grade intoxication, the cause of which cannot always be determined. At least under its use patients report to me that they feel much improved and I have noticed personally that they look better, are more active and seem to have more energy. As a measure of therapy I believe it has some value.

Physical Adjuvants during Operation: I have had no experience with the method of Crile by which during operation he claims to decrease the incidence of shock to the patient, by passing a high frequency current through the liver, thereby raising the general body temperature. Perhaps this may be of value but from a theoretical standpoint, to my mind, it is not ideal. It is of course necessary during an operation to keep the patient from losing heat, but in a series of 20 operations where rectal temperature curves were plotted, I found that under ether anesthesia there was a constant but slight elevation of temperature.

I find that the physical measures which may be considered as applicable at the time of operation are those modifications of the high frequency current by which fulguration, desiccation and acusection can be performed. It is a great boon to the surgeon to be able to destroy tissue in situ by means of coagulation or desiccation or to remove neoplasms and other growths by means of the high-frequency-cutting current. I have made many incisions through the abdominal wall by the endotherm knife. At times I used it with considerable apprehension and perhaps was unjustly fearful of non-union or extensive necrosis. In some cases where the bowel was attached to the under surface of the abdominal wall, I thought that I might, on making the incision, penetrate into the bowel. All these fears were groundless.

The control of bleeding vessels by coagulation of vessel wall does away with ligatures and has proved a great boon to the modern surgeon. Of all the advancements in the technic of surgery in the last decade, it seems to me that the practical

application of the high frequency current in coagulating dissication and of incisional cutting because of its unique and useful character, is the most valuable.

Postoperative Treatment: In the postoperative treatment of surgical cases those in which abdominal adhesions have been present and in which we apprehend a recurrence of adhesions after operation, peristalsis is stimulated by diathermia and I believe is of value in retarding the formation of the intra-abdominal adhesions. Immediately after operation injection of eserine salicylate and pituitrin is given in association with diathermia. A pad moistened with sterile 10 per cent salt solution is placed over the abdomen with the counter electrode over the back. Low amperage is applied for at least one hour. Increase of peristalsis can be definitely determined by listening through a stethoscope placed on the abdominal wall. The patient feels markedly benefited by this treatment.

Nature is extremely beneficient in its endeavor to induce reactions favorable for healing. Under all the reactions in which healing occurs there is a hyperemia and increased circulation. In consequence, accumulation of corrective factors and reconstructive agents associated with an increment of nutritive elements occurs. In physiotherapy there are two agents which can induce such results. First, ultraviolet radiation which is obtained directly from the sun or by artificial means from carbon arcs or mercury lamps. The manner in which ultraviolet light acts on a part has been the subject of considerable controversy. However, I believe that we can say without fear of contradiction that one effect of this application is hyperemia produced directly in the part under treatment. This hyperemia may be the result of the heat from the lamp or may be the effect directly from the action of radiant energy on the sympathetic nervous system or of both so that the vessels of the part under treatment are dilated. Ultraviolet radiation also has a peculiar tendency to cause an increase of calcium in the blood. Calcium as you know again acts upon the sympathetic nervous system, produces dilatation of the vessels and seems to be specially localized to any pathologic process taking place in the body, so that its actcivity becomes more centered upon that localized and pathologic area. It evidently stimulates the formation of red blood cells and produces a hyperemia of the surface vessels of the skin. It is of value in increasing the amount of blood serum calcium and its mobilization in the system.

Massage should not be neglected as a postoperative routine. After abdominal operations it should be applied very carefully over the abdomen. As a general stimulating agent it is of considerable value. A nurse in a doctor's office can apply it very beneficially. Mild degrees of exercise should be instituted very early. An ideal method would be shortly after operation to begin and have those who are able do some well-planned resistant movements. So far I have not applied massage as a routine but believe it of great value, and that good results undoubtedly are to be obtained from its use. Massage may be combined with other physical measures of treatment so that the circulation of the part is stimulated or mobilization of tissues, reconstructive elements takes place. After fractures, massage is of very great benefit.

Where operative interference has induced an induration of tissue, perhaps as the result of trauma or of hemorrhage, and in lesions due to a type of organism which does not induce definite suppuration, radiant light has given good results.

In certain individuals, after trauma, either operative or accidental, there is a rapid proliferative growth of scar tissue, which is termed a keloid. These keloids in the course of their rapid growth may become very painful. With direct application of a Kromayer lamp, keloids are not only controlled but the pain disappears and the tissue becomes soft and pliable. In

every patient ultraviolet light should be applied as soon as a tendency for keloid formation is noticeable in a scar.

In an abdominal postoperative patient there is nothing which arouses more anxiety than do hiccoughs. It is, in many instances, the label for sepsis and the forerunner of death. Even after basic causative agents have been removed as much as is possible, the spasmodic contractions of the diaphragm may persist and cause complete exhaustion. Every surgeon of experience encounters such a condition, every once in a while, and if he does not correct it is aware that death is reaching for his patient.

In a patient, an infected foot was incised and a piece of necrotic bone was removed from the end of the third metatarsal. General sepsis developed and hiccoughs started, which could not be controlled by the usual methods of treatment. Even phrenocotomy was unsuccessful. The spasms still persisted though lessened in severity. Morphine and narcotics had no effect. The patient, though sleeping, would continue to hiccough, The only way the hiccoughs could be controlled was by the interrupted galvanic current, the positive electrode over the epigastrium and the negative electrode on the opposite side of the body. After ten minutes of application with 20 ma. dosage the spasm would cease and patient sleep quietly. In a few hours the hiccoughs would again start and would cease on application of the galvanic current.

Arthritis: Among the diseases that are particularly in the province of the surgeon are various forms of arthritis. Heretofore the surgeon has assumed charge of a patient with arthritis only when the process has become suppurative. If the surgeon is called upon to treat a case of arthritis, he should first determine whether it is suppurative. I prefer to refer to a medical clinician all forms of arthritis except the static, traumatic, tubercular and suppurative.

When a surgeon assumes responsibility of a patient with arthritis, he should consider not only the means which heretofore have been used by him, such as splinting, application of ice, or heat, to the part; but should also avail himself of the beneficial influences of physiotherapy, remembering that in every person generalized radiation by ultraviolet light increases the general and indirectly the localized resistance to disease. He should remember, particularly, that all chronic suppurative processes are improved by penetrative heat, even when pus is present though it may be necessary to make an incision into the part and evacuate the pus. The involved joint should be placed at rest in order that diathermia and radiant heat may be used to the best advantage. This method combining generalized ultraviolet radiation with localized radiant heat and diathermia, is valuable for the relief of symptoms and as a means of bringing the joint back to approximately normal function.

Bier's hyperemia also is most useful. At the German Surgical Congress of 1913, I saw Bier present over 100 cured tuberculous arthritic cases with nearly perfect motion in the joint.

Fractures: Diathermia and ultraviolet rays are to be highly recommended in the treatment of fractures. In these cases also one should not forget that Bier's hyperemia is very definitely indicated.

The diathermia should not be used too early i.e., before the callus has begun to form. There is a growing opinion that hyperemia in the very early stages of a fracture hinders the repair. Massage, by keeping the muscles in a healthy condition, is valuable.

Stimulation by faradic and galvanic currents keeps the muscles in a healthy state so that on resuming activity they can immediately function at full capacity.

Ulcers: Indolent ulcers on the leg are the bane of every surgeon. He has found them extremely difficult to heal and even when cured it is very hard to keep them permanently healed. Many of these ulcers are due to the stasis resulting from varicose

veins. The removal of these veins will aid and sometimes cure. Varicosities are now usually treated by local intravenous injection of an agent which is destructive to the intima of the vein. However there are a certain number of these ulcers which do not heal even when the associated varicosities are corrected. There are also a certain number which are not associated definitely with any varicosity. In these, one should seek for a diabetic or syphilitic basis and especially should the blood-sugar be estimated. There is a further group of which the causative factor is extremely difficult to determine. This group in which ulcers are indolent do not have a red granulating base but a grayish floor, the edge is not abrupt nor elevated but seems to slope gradually towards the floor of the ulcer. Epithelium as is known will not heal unless there is granulation tissue, over which it can grow. As these ulcers do not have granulation tissue at the base, it is necessary to stimulate formation of this tissue by irritation with silver nitrate or with the cautery. It is also necessary to keep the circulation of the limb in a high degree of efficiency. The ultraviolet light, the radiant light or diathermia is of considerable value. In one case I have applied the galvanic current with the idea that it would produce a relaxation of the vessels in this area, the current being sent both in a transverse and a longitudinal direction across the ulcer, and reversed frequently. I noticed marked improvement.

Tuberculous Glands: Until recently tuberculous glands were absolutely in the province of the surgeon. I, as well as many others, have removed numbers of them, especially the cervical glands of the neck. If conservative we have subjected our patients to repeated operations in the same area, or if radical, have made a very wide excision with a noticeably disfiguring scar. In the last five years I have not operated upon a single tuberculous gland of the neck. If the gland is broken down but does not communicate with the surface I have aspirated the liquid contents through a needle. I find that it is not necessary to incise these glands and that they recover without scar, without deformity and without the induction of additional drainage. In some instances I treat them according to the method of Calot. When these glands are operated it happens too often that the surgeon scatters the tuberculous material so that he directly is the means of extending the process further along the lymphatic chain. Lymph adenitis usually responds very readily to radium the *x*-ray or the Kromayer lamp. As a means of keeping up the nourishment of the patient to a high level, cod liver oil, iodides, good food and plenty of rest should not be neglected.

Pelvic Cellulitis: A further field which has been preempted from the surgeon to a considerable extent is that of pelvic cellulitis. I can well remember the time when every patient with pelvic cellulitis beyond the acute stage was considered a legitimate case for myself and associates. I was very much surprised in 1926, while attending the gynecological clinics in Vienna, at the few operations for pelvic infections which were performed. In one whole month I did not see operated a single case of pelvic cellulitis. The personnel of the clinic informed me that pelvic cellulitis was treated entirely by heat from hot mud baths and diathermia. The patient enters the mud baths and stays in them for a considerable period. Diathermia was used according to the technic which is customary. Every one of the patients that I saw was doing well under this form of treatment. Each patient was also given protein therapy. In the past four years I have closely followed this plan. I found that in a few cases I had to operate to remove an infected tube. By removal of the tube or tubes, if both are involved, I have been able to accomplish good results. I operate only when importuned by the patient who does not have the time nor the inclination nor the means to continue treatment over a long period. I believe that in 90 to 95 per cent of all cases cure would

follow should the physical methods of treatment be sufficiently persistent.

I have found the direct application of the Kromayer quartz rod of very great benefit in the healing of cervical ulcerations and in the cure of discharges, non-gonorrheal in character, which apparently have their origin in the endocervix.

SUMMARY

I am convinced of merits of physiotherapy used in European Clinics.

I am well satisfied with the apparatus for the physical treatment of disease in my own office.

I use ultraviolet light, radiant light, baking, sinusoidal current, also *x*-ray, radium, massage and heat, each application having its own particular field.

I do not use hydrotherapy, though I believe it to be of great value.

A correct diagnosis must first be made in order to select the proper physical measure of treatment.

The treatment must be prolonged and consistent. It will shorten the period of disability in practically all cases following accidents and injuries.

Physical therapeutic measures must not be blindly applied. At least a general if not a detailed knowledge of their effects must be possessed.

They are of great value and will increasingly become more used in the treatment of fractures, of abdominal adhesions, chronic pelvic inflammation, proliferative cars tissue, and in general infections, both acute and chronic.

R. J. Behan.
Pittsburgh, Pa.

THE RADIOLOGIST AS A CONSULTANT

THE radiological editor has on previous occasions expressed his opinion regarding the ideal relation between the radiologist and the hospital, though much remains which might be said on the subject. It is quite evident that in the average community there is a definite tendency to regard the radiological department of the hospital or the radiologist working in private practice as more or less exalted photographic agencies. Only in the exceptional case does the radiologist function as a consultant in the ordinary sense of the word, and in these instances it is because he has by long years of experience worked himself into that position through the excellence of his radiographic performance combined with a high average of correct interpretation and the exercise of diplomacy in his relation to professional colleagues.

This subject has recently been considered by G. B. Batten writing in the *British Journal of Radiology* for June, 1930. Batten asserts that the requirements of practicing clinicians from medical radiologists should be exactly the same as the requirements of clinicians from all other qualified specialists; they should apply for and require from the radiologist such aid as will help them to diagnosis and treat their patients in the best possible way for their patients' greatest good. Most of all the clinician requires from the radiologist painstaking fluoroscopic observation, really good films and a careful, well-considered report.

Batten then goes on to emphasize that there is a converse to this proposition and that the radiologist also requires something of the clinician if the best team work is to result. He should demand and obtain everything that any other specialist would require from the clinician to help him to elucidate the problem necessary for the correct diagnosis, and, therefore, for the correct treatment of the patient. He should be given as much of the history as a wise clinician would give to any other specialist and which he believes would help in ascer-

Walter M. Brickner

[EDITOR OF THE AMERICAN JOURNAL OF SURGERY, 1905-1928]

The American Journal of Surgery
N. S. Vol. IX, August, 1930

taining the truth about the patient's health. These details would not necessarily be the same in a patient's history when the clinician sends him, for instance, to a bacteriologist or to a radiologist. The important thing is that the clinician should take the radiologist into his confidence, and state in which directions his help is needed. Under such circumstances it will often transpire that the radiologist will be able to suggest additional ways of seeking help which may not have occurred to the referring physician. It is important to bear in mind that the *x*-ray and clinical methods are "complementary, not competitive" methods of investigation (Barclay).

The relation of the radiologist to the patient should also be carefully considered, especially in view of the exaggerated belief the public have that an *x*-ray examination can reveal anything and everything. It is sometimes very difficult to answer the pertinent and anxious inquiries of the patient, and it is often just as difficult to make no answer, especially when the patient imagines that things are worse than they are and that the clinician will not tell him the truth about the consultant's opinion. The radiologist must be as wise and as reticent as possible in such cases, without unduly exciting the patient's fears. Someone has suggested that if patients are anxious and demand to know the result of the radiological examination, the radiologist might say, "I have only part of your story. If I took down a book from that shelf and tore out a few leaves and gave them to you, you would think it a silly proceeding, because you would not have the finish of the story; neither have I."

The radiologist should treat the clinician in a truly professional and consultative way, as Batten says, making it his aim to help him in every way for the patient's benefit without spoken or implied criticism of any opinion the clinician may have expressed.

James T. Case.

Dr. Walter M. Brickner, who was editor of The American Journal of Surgery from 1915–1928, died of angina pectoris at Atlantic Beach, Long Island, July 22, 1930, in his fifty-third year. The American Journal of Surgery is glad to be able to publish the following appreciation by one of his best friends

WALTER M. BRICKNER

(1876-1930)

AN APPRECIATION

Howard Lilienthal

A handsome, slender, bright-eyed youth, Walter Brickner appeared before the Examining Committee at Mount Sinai Hospital competing for a place on the House Staff. It was then that I first met him. I was assisting Dr. A. G. Gerster, Examiner in Surgery.

The Phi Beta Kappa symbol gave promise of scholarship and brilliancy which was confirmed as soon as he began to speak. He easily won the honors of the examination.

Throughout his Hospital Service Dr. Brickner displayed, in addition to the expected conscientiousness and industry, a delightful whimsical humor which lent a charm to everything he said or did and gave much joy to his many friends both within and outside the profession.

With the skill and originality which

brought success in Surgery, a fine technical quality set his writing at a high level and distinguished the character of his contributions to the literature. Especially in his work on the treatment of actinomycosis of the pelvic recesses and in his articles on subacromial bursitis there was a clearness of thought and expression which made reading easy and which forcefully carried his message. What more natural than that with such talent he should be attracted to the field of medical journalism and that finally he should achieve a prominent editorial position. For many years, under his management, the American Journal of Surgery developed and became more and more attractive to important contributors both here and abroad.

The World War reached out and at last drew our country into its grip. To Captain Brickner, later Lieutenant Colonel, was given the responsibility of assembling the group of men who became the enlisted personnel of Base Hospital No. 3, also known as the Mount Sinai Hospital Unit. With prophetic insight he selected from the hundreds who applied, those who were best qualified to fill the many and varied stations which were to be parts of a great military hospital. Steam fitters, bakers, carpenters, chiropodists, business men, bookkeepers, druggists, chauffeurs—all in correct proportion, rich and poor, were made into one orderly body; and when the time came for us to take up the assigned task our parent Hospital in New York was right to be proud of us.

Overseas Dr. Brickner, then a Major, rendered valuable and patriotic service both at the Base and in Evacuation Hospital No. 8 near the front. Through it all his exquisite humor never failed while his personal care and tender sympathy gave last comfort to those whom his skill could not save.

Back from the War Colonel Brickner, now once more a New York Surgeon, became active in military organizations and, for a time was Surgeon on the Staff of the Manhattan Chapter of the Military Order of the World War.

He resumed his position at Mount Sinai Hospital and later became Chief Surgeon of the Hospital for Joint Diseases. Dr. Brickner was also honored by an appointment as Skeletal Surgeon to Morrisania Hospital.

He was a Fellow of the New York Surgical Society and of the Academy of Medicine and was associated with other professional bodies.

And now, at the height of his career, he is gone! All those who knew him grieve over the loss of a faithful friend and comrade while our profession will sorely miss an outstanding figure.

Subscribers to The American Journal of Surgery *visiting New York City are invited to make the office of the publishers (Paul B. Hoeber, Inc., 76 Fifth Avenue, New York) their headquarters. Mail, packages or bundles may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

BARTOLOMEO EUSTACHI

[1524-1574]

The American Journal of Surgery
N. S. Vol. IX, August, 1930

"EUSTACHIAN TUBE"

HE was called Eustachius. His name was Bartolommeo Eustachi. He was one of the early anatomists now called great, and he stands a mountainous figure against the background of his time. He was born in 1524, a romantic age; also, a dangerous age for free thinkers and those with exceptional talents. In the main Galen's teachings were accepted as scientific finalities up to the advent of Vesalius. Thereupon was inaugerated a new era that many years later gave birth to what we term modern medicine. However, although Eustachius was a natural genius in discoveries, at the same time he was opposed to accepting the newer teaching. He remained a Galenite.

Eustachius was professor at the Collegia della Sapienza in Rome. Here, in 1552, he completed his "Tabulae anatomica." This, in the main, has kept his name fresh to posterity. He drew the plates but they remained unprinted in the Papal Library for one hundred and sixty-two years. Then Pope Clement XI made a present of the engraved plates to his personal physician, Lancisi, who sought the advice of Morgagni, another anatomical genius. Morgagni urged that they be published. In time they were published by Morgagni who combined them with his own notes (1714). These were the first anatomic plates on copper.

Eustachius is credited with the discovery of many things. He discovered the Eustachian tube, the thoracic duct, the suprarenal bodies, the abducens nerve, and also described the origin of the optic nerves, the cochlea, the pulmonary veins, the muscles of the throat and neck, and gave the first correct and accurate picture of the uterus. He is credited with having written what was in his time the best treatise on the structure of the teeth, giving the nerve and blood supply.

He died at an age today called young. Then, when life was not a simple affair and humans aged before maturity ended, he no doubt was called an old man. At his death in 1574 he was fifty years old.

T. S. W.

[From Fernelius' Universa Medicina, Geneva, 1679.]

BOOKSHELF BROWSING

STUDIES IN PALEOPATHOLOGY, XXVI

PLEISTOCENE LUXATIONS*

ROY L. MOODIE, PH.D.

SANTA MONICA, CALIF.

INTRODUCTION

THE purpose of this paper is to describe accurately and interpret logically, the types of luxations seen in the skeletons of the Pleistocene mammals from the Rancho la Brea. Some of the elements showing partial luxation had been fractured and one of these bones has been described in another connection and is noted further on.

A study of the relation between the angle of torsion of the femora of the giant wolf and luxations has been considered in this study to see if the twisting of the shaft can have had an influence on the degree of luxation. I shall devote a section of this essay to a consideration of the problem of torsion.

I have been engaged in this study during several years, and have discussed the problems involved with several individuals experienced in orthopedic surgery. My chief obligations are to the members of the staff at Hamann Museum of Western Reserve University. Dr. Todd came to Los Angeles and went over all the materials with me, and I have profited greatly from his suggestions.

Three types of arthritic disturbances are described in this paper. The first is that of loss of head of femur due to an infection in the hip-joint. Second, the complete luxation of traumatic origin, and third, partial luxations as described in the pelvis of the sabre-tooth and in a femur of the same animal, as well as numerous examples in the wolf. One has to make an arbitrary choice from the wolf material for there are dozens of examples of arthritic disturbances grading out from partial luxations to very slight arthritides.

MATERIALS

I have had entire access to the unrivalled collections of Pleistocene mammals from the Rancho la Brea at the Los Angeles Museum, where there are many thousands of limb bones and pelves, chiefly of the giant wolf and sabre-tooth. I have examined the entire collection of great ground

* I am under special obligation to members of the staff of Hamann Museum, Western Reserve University, Cleveland, Ohio, for help in the interpretation of the lesions described in this paper. Dr. T. Wingate Todd compared the fossil bones with specimens in the Museum and furnished photographs. Dr. C. A. Hamann sent very welcome financial aid with which the illustrations of this essay were secured. Dr. N. William Ingalls determined for me the angle of torsion in a series of twelve selected femora of the giant wolf. Submitted for publication September 13, 1928.

sloths, sabre-tooth cats, and several other species of mammals, and the luxations described here are about all there are. The greatest number of luxations, partial and complete, occur among the giant wolves. It will be at once evident that in a territory teeming with enemies, as was this part of southern California, during the Pleistocene, an animal with a dislocated joint would be so severely handicapped that his continued existence would be very doubtful. He would soon fall a prey to his enemies.

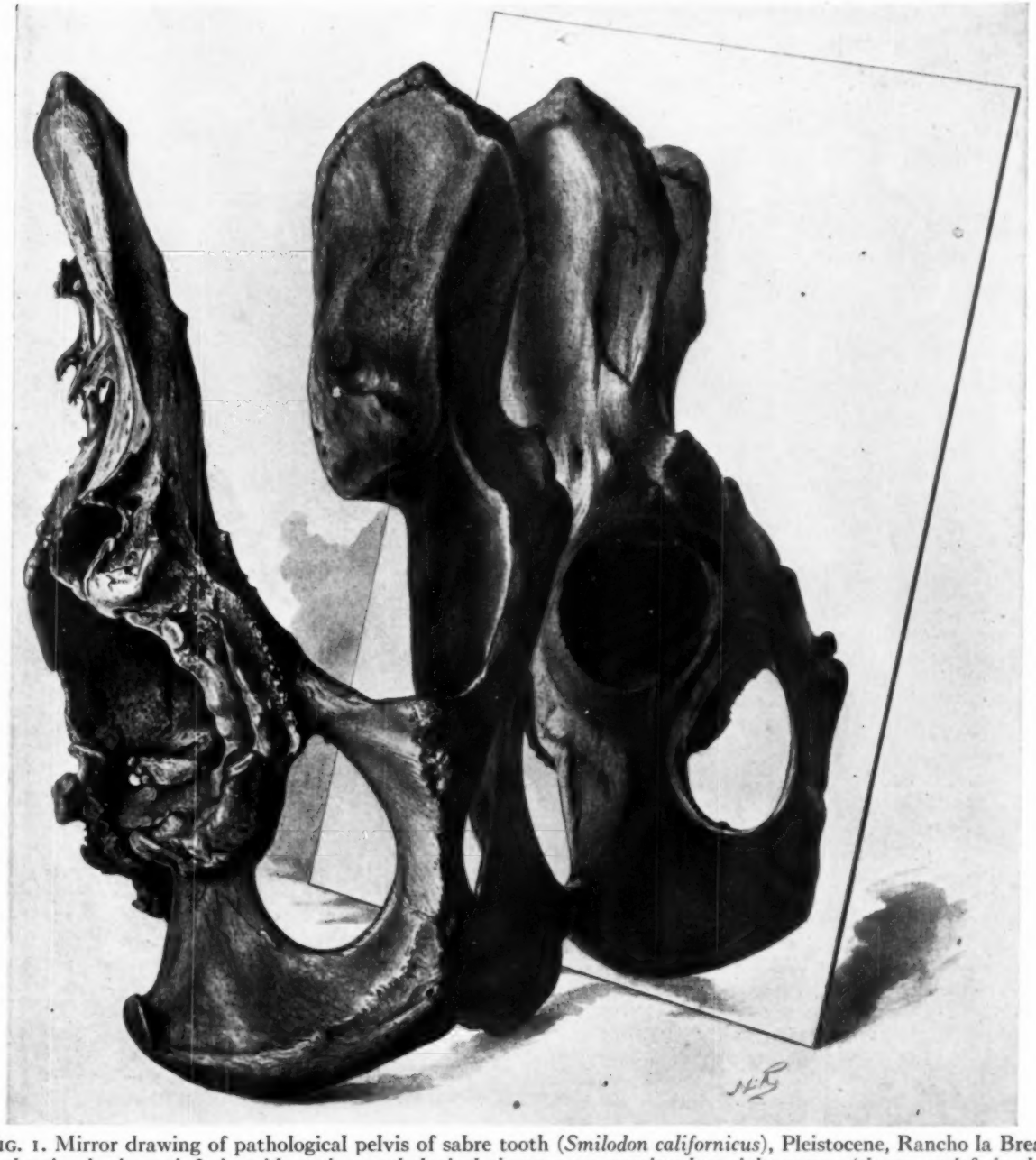


Fig. 1. Mirror drawing of pathological pelvis of sabre tooth (*Smilodon californicus*), Pleistocene, Rancho la Brea, showing both rami. It is evident that pathological changes are restricted to right ramus (shown on left in the picture). All other parts of pelvis are normal. Drawing depicts oblique, ventral view of pelvis, with diseased, distorted acetabulum, and surrounding areas, to left. On right of picture the left acetabulum and pelvic ramus shown, reflected in a mirror, indicated by rectangular field. Eburnated area of diseased acetabulum shown to extreme left. Another view of pathological ramus shown in Fig. 9. Drawing by John L. Ridgway.

I have measured several hundred femora

of the giant wolf with an osteometric board, and have determined the degree of torsion with a tropometer loaned me by the San Diego Museum, in an attempt to determine the factors underlying luxation. I examined, individually, 1945 femora of the sabre-tooth tiger, as well as all other limb bones of this species, including the metapodials, to the number of many thousands so that the accompanying account is based on a survey of an enormous amount of material. All comparative statements have been checked again and again and every care has been taken to diagnose the lesions in an open-minded way.

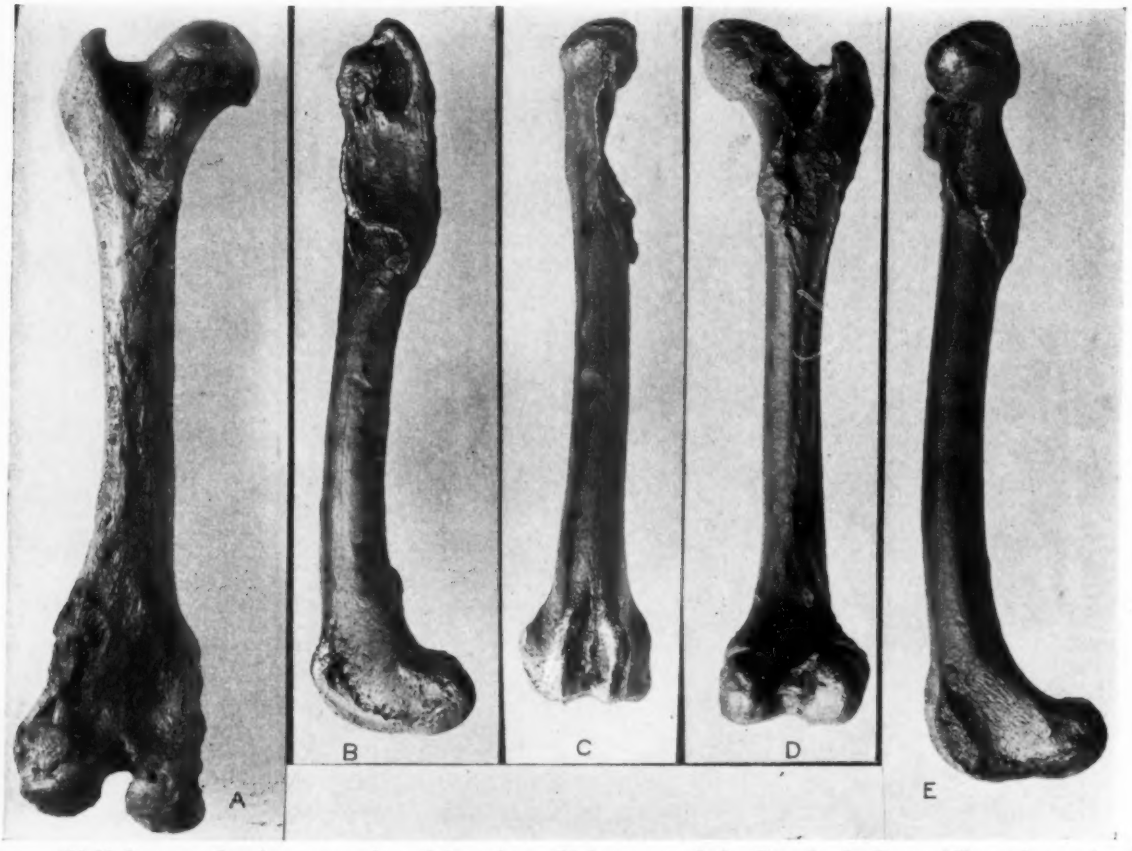


FIG. 2. Wolf femora showing examples of luxations. Pleistocene of the Rancho la Brea. All specimens in the Los Angeles Museum.

A = Small wolf femur, 210 mm. in length, with angle of torsion of 7.5°, showing changes in form of head resulting from fracture in lower one-third. The shaft is unusually short and straight. Another femur, 270 mm. in length, longest femur in collection, is uninjured, but shows angle of torsion of only 2.5°. It is not certain that the short femur shown in "A" is of same species as others figured, it being impossible to tell the effect the injury has had on the growth of bone.

B = Right femur of giant wolf, *Aenocyon dirus*, an extremely rare condition, visceral aspect, showing deforming effect of articulation in absence of *C put femoris*. Length of femur 230 mm., angle of torsion cannot be determined. Compare with kangaroo femora shown in Fig. 5.

C = Same bone, anterior aspect.

D = Right femur of giant wolf, *Aenocyon dirus*, showing deforming effect of *acquired luxation* due to violence. Lower portion of articulating surface is eburnated. Its extent on to shaft of femur may be judged from "E." The length of the bone is 256 mm., with a degree of torsion of 8+°. The pelvis shown in Fig. 3 is definitely ascertained to belong with this femur, although it was found isolated. It matches perfectly. It is clear that the head of the femur was completely dislocated from the acetabulum and formed a false joint. The luxation was intracapsular. The *Linea aspera* is extensive, doubtless in response to the luxation.

E = Same femur shown from inner aspect. Inferior articular surfaces are not seriously affected.

REVIEW OF LITERATURE

There does not exist in the literature of paleontology, which I have seen, any discussion of Pleistocene or earlier luxa-

tions. Baudouin (1907) after an extensive outline of congenital luxations gives an account of four Neolithic femora which he thinks belong with this type of dislocation. Changes in the heads of the femora lead the author to this classification, but he does not clearly differentiate from the similar conditions following prolonged sepsis.

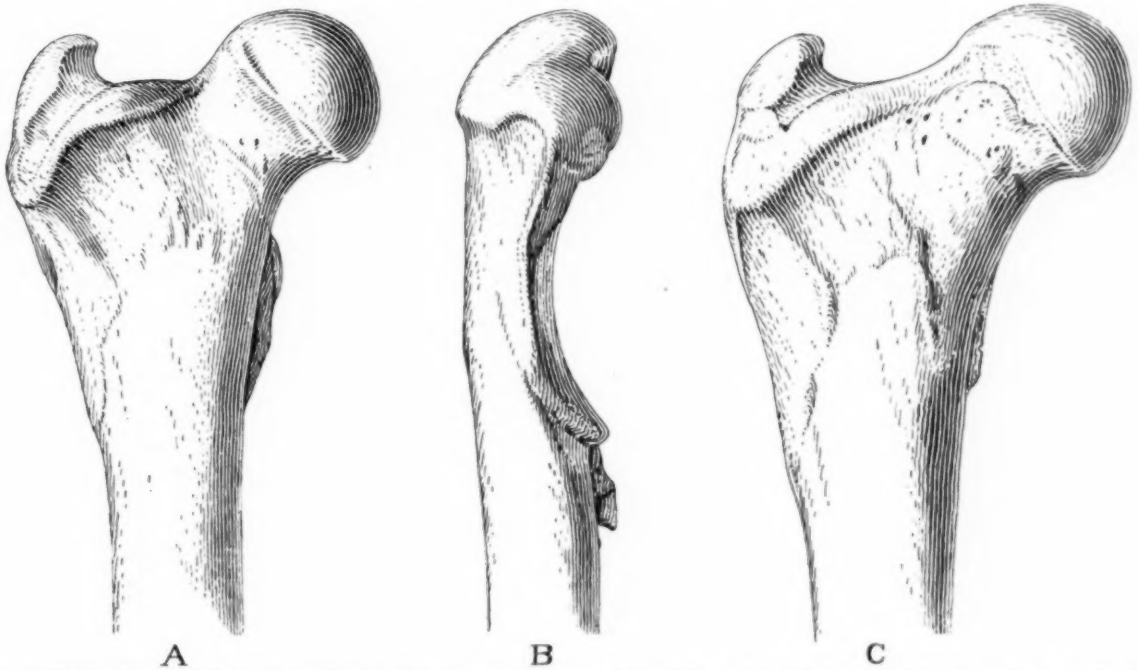


Fig. 3. Right femora of giant wolf, showing different forms of head in A and C in normal bones, and in B articular part of femur showing luxation. Femur in "C" is 270 mm. in length with angle of torsion of 5°. All three femora believed to represent *Aenocyon dirus*.

Fox has described one example of acquired luxation in a captive wild mammal but does not discuss the bone changes.

Job's paper (1891) is of importance. After a review of the literature and a discussion of Broca's tropometre, he describes a new instrument, the trepsimetre, for the determination of torsion. The normal human femur has an average degree of torsion of 12°, a maximum of 25° and a minimum of 3°. Short femora have a greater angle than long; the left more than the right. Pathological femora (fractures, osteomyelitis and genu valgum) are subject to luxation. A femur with an osteomyelitis has a torsion angle of 49°.

Verneau (1903) describes and figures a pre-Columbian luxation from southern Patagonia in which the acetabulum is completely destroyed and a new articular area extending vertically in a wide trough about two-thirds the length of the pelvis. There is no evidence of eburnation. The femur is not described.

A pre-Columbian pelvis from Peru showing arthritic changes due to luxation is in the Peabody Museum of Anthropology at Harvard University.

TYPES OF LUXATIONS SEEN IN PLEISTOCENE MAMMALS

There are, of course, two general types of luxations to consider, and into these groups certain of my specimens naturally fall. Examples of congenital luxation are entirely unknown among vertebrates other than man. Baudouin (1907) speaks of the condition as the "Maladie anthropologique par excellence!" When I first came to the Los Angeles Museum several years ago the first thing to attract my attention was the wolf femur shown in Figure 2, B and C, and the thought that flashed into my mind was *congenital luxation!*

I held this opinion for some years and it seemed to be confirmed by conditions in an adult kangaroo but subsequent study brought another interpretation as outlined later. The absence of a *Caput femoris* has another explanation. A special search for the pelvis accompanying the wolf femur was made through the Los Angeles collections without success.

Fig. 4. Fragmentary right pelvis of giant wolf which is exactly matched with femur shown in Fig. 1, D and E. The fragment is 159 mm. in length. The acetabulum is almost obliterated, and the functional, new, articular surface is extensively eburnated, with considerable hyperostosis.

Fig. 5. Femora, pelves and sacrum of a recent kangaroo, which in life had acquired considerable reputation as a "boxing kangaroo" in one of the Los Angeles Zoological Gardens. Skeleton in Los Angeles Museum.

A = Right femur showing effect of (congenital?) luxation and consequent lack of *Caput femoris* in producing new articular surface with associated surface on pelvis. Length of femur 248 mm.

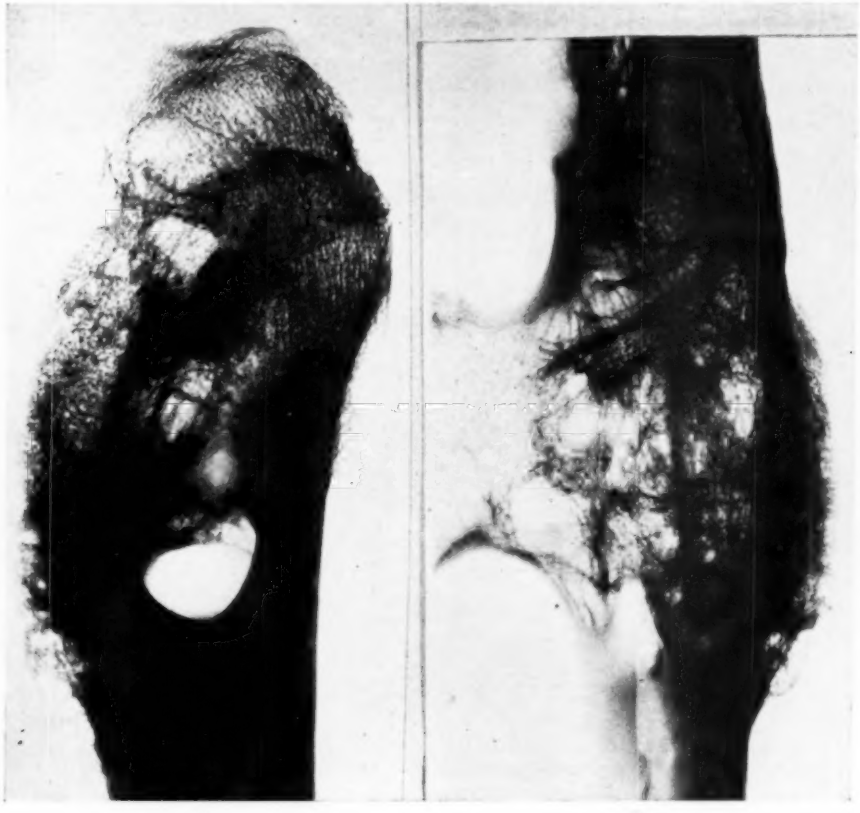
B = Left femur.

C and D = Right and left pelves, with greatly modified acetabulum, and eburnation of new articular surfaces.

E = Sacrum.

Acquired luxations are those due to injury after or during birth, to disease, to an exaggerated degree of torsion of the shaft of the femur or humerus; thus rendering luxations easier to acquire, or to a combination of two or more factors. I shall describe an example of luxation due to violence in a giant wolf in which I have the good fortune to possess both the pelvis and the femur (Fig. 2, D and E and Fig. 4). A most interesting example of an acquired luxation is seen in the pelvis of a

sabre-tooth (Fig. 9). There are numerous examples of partial luxations accompanied by more or less extensive arthritic lesions.



A B

Fig. 6. Articulating areas in hip-joint of kangaroo.
A = Arrangement of trabeculae in head of femur. B = Same in acetabular area of pelvis.

A few of these will be described in this place.

Bone Changes in a Modern, Human, Septic Hip

The search for human examples showing loss of head and neck of the femora, with which to compare our Pleistocene wolf (Fig. 2, B and C) and the kangaroo (Fig. 5), resulted in the acquisition of the roentgenogram by Dr. Todd, shown in Figure 8, based on a septic hip in a young girl at Cleveland. An examination of the femoral head on the right of the picture shows loss of head and neck, and a pushing up of the femur so that the articulation with the pelvis is on the upper part of the femoral diaphysis, exactly as is to be seen in the wolf and kangaroo mentioned previously.

This is not congenital luxation, but an acquired luxation following a chronic infection (osteomyelitis?) of the hip. Traces of infection in the wolf femur and in the kangaroo femora and acetabula are elsewhere noted, and it is probably safe to state that the Pleistocene wolf femur (Fig. 2, B and C.), the kangaroo hip (Fig. 5) and the modern child (Fig. 8), are all to be assigned to a similar cause, chronic infection of an unknown type.

An examination of the roentgenograms of children's hips given by Rotch (1910) sheds some light on the present conditions, though none are so clearly paralleled as the case shown in Figure 8.

Comparisons of Pleistocene Wolf Femur with Human Bone

The wolf femur (Fig. 2, B and C) may be regarded as of the same type of change as that shown in the child's hip (Fig. 8), as well as that of the kangaroo (Fig. 5). These three examples, human, wolf and

kangaroo, all show loss of head and neck with almost the same gross features in all.

The femur (Fig. 2, B and C; Fig. 3, B) is

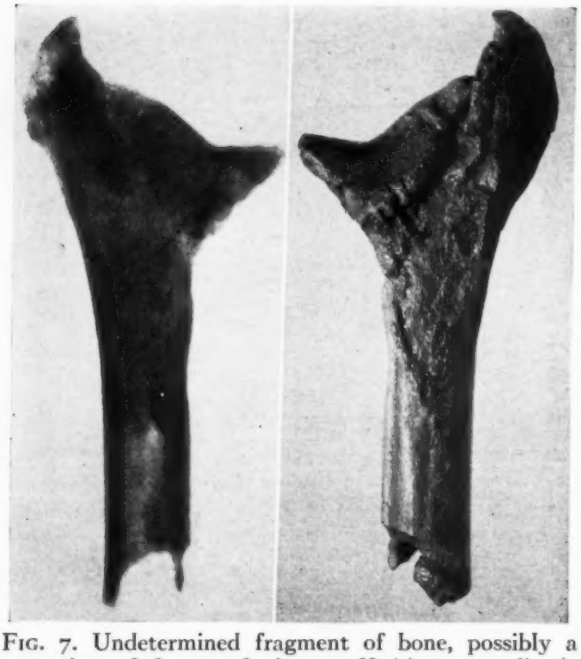


Fig. 7. Undetermined fragment of bone, possibly a portion of femur of giant wolf (*Aenocyon dirus*), showing false joint, a pseudarthrosis, with some excess callus. It has not been possible to associate this interesting fragment with any other bone in the collection. It indicates an ankylosed hip-joint with pseudarthrosis in upper one-third of femur. Pleistocene of the Rancho la Brea, specimen in Los Angeles Museum at Exposition Park. X-ray by Dr. L. C. Kinney.

unique, and the large collections from the Rancho la Brea show nothing similar. A special search was made through the collections for the pelvis belonging with this femur without success.

The articular area of the bone (Fig. 2, B) measures 30 mm. x 75 mm., and articulation seems to have been restricted to the lower part of the area. There is no eburnation of any part of this area, but there is some excess callus at the lower part.

I am unable to explain the deep pit at the top of the area. There are several of them in the kangaroo femora (Fig. 5). It may be a necrotic sinus, though there is now little evidence of a severe infection.

The lower articular surfaces of the wolf femur are not affected, nor are those of the kangaroo.

We are fairly safe in asserting that the loss of the head and neck in the fossil wolf, the kangaroo and the child was due to the same cause in all, sepsis. The nature of the sepsis in the Pleistocene example cannot be determined.

FEMORAL TORSION CONSIDERED AS A FACTOR IN LUXATION

It is a recognized fact that in the human femur there is normally about 10° to 12° anteversion of the head from torsion of the bone, and in a very large percentage of cases of congenital dislocation of the hip it exists to a much more marked degree, even as much as 90°, so that it is believed that in the cases of marked torsion deformity, the deformity is the cause of the dislocation, and that probably the dislocation did not occur until after birth from use of the deformed bone.

Job found torsional angles in human femora from 3° to 25° which had no marked influence on luxation.

In the twelve wolf femora studied by Dr. Ingalls the angles were found to vary between 1° and 13.5°. This series may be changed by a study of a larger series of bones, but the twelve were especially selected from several hundred.

The method employed in determining the torsional angle in the wolf femora is essentially the same as that employed for a study of human femora. The axis of the head and neck and the center of the head were determined by a Koordinatenzirkel. The long arms of the instrument were both in contact with the head at its greatest diameter and at the same time parallel with what has been considered the neck of the femur for present purposes. This concerns the outline of the neck as seen from above but only that portion on the same level as the head. The lower, flaring part, running down to the lesser trochanter has been disregarded. The neck in the wolf femora is so different from the human condition that it was not possible to determine its midpoint by any direct measurement. The great

trochanter was also left out of account so what was considered as neck is that portion of the bone from 1 to 1.5 cm. in extent, perpendicular to the long axis of the bone, but this is of no consequence since the angle of obliquity is small.

Fig. 8. Pelvis of a white girl between seven and nine years of age. Her history is one of perfect ability in walking until between two and three years ago (November 23, 1927), when she developed an abscess of left hip and was in bed for several months. Thereafter she had a marked limp. She had all of the symptoms of acute inflammation of hip-joint. It is clear that there is complete absence of head and neck (right), without interference, at the epiphyseal line of the great trochanter. Picture from Dr. T. Wingate Todd.

immediately lateral to the head, as seen from above, is the long axis of the bone.

The short middle arm of the Koordinatenzirkel, set at one half the anterior-posterior diameter of the head, marked the center of the head when the long arms were parallel with the axis of the head and neck. The placing of the arms parallel with the axis is purely a matter of judgment or appreciation and involves naturally the estimation of the desired axis and then the placing of the caliper arms parallel to this. The angle determined, the torsion angle, is the angle formed by a line or plane joining the determined points and the retrocondylar plane, which is tangent to the condyles and the trochanteric region. The plane in which the torsion angle lies is

Judging from a comparison of the angle of torsion of the wolf femora with those found in human femora it is concluded that the angle in the Pleistocene wolf is too small to have been of any significance in producing luxations.

Table 1

A list of wolf (Aenocyon dirus) femora showing various degrees of torsion

	Length (Mm.)	Torsion (Degrees)
1. Normal right	225	6
2. Luxated right	256	8+
3. Normal right	271	11
4. Normal left	253	10−
5. Normal right	238	6+
6. Normal right	242	9
7. Normal left	258	5+
8. Normal left	238	1−
9. Normal right	270	2.5−
10. Fractured left	210	7.5
11. Normal right	235	7.5+
12. Normal left	254	13.5

FIG. 9. Right ramus of an adult sabre-tooth tiger (*Smilodon californicus*) Pleistocene, Rancho la Brea, showing lateral surface, extensively diseased. Luxation incomplete, and eburnated articular surface used is shown on left of acetabular area. The extensive pathological growths are without parallel in the field of Paleopathology. They are regarded as due to severe bacterial infection following injury which produced the luxation. What kind of injury effected these changes is unknown, but it was severe. Nearly 2000 femora of the sabre-tooth were examined in an attempt to find the bone which belonged with this pelvis, without success. Doubtless a discharging abscess poured out pus for a considerable period of time, and probably had not healed at the time of the death of the animal. The opening in the floor of the acetabulum is, in part, accidental. The bone was extremely thin and was fractured in collecting. Pelves and sacrum seldom associated in sabre-tooth remains. Only in pathological cases involving the sacroiliac joint are associated parts retained. Pelvis is shown from another angle in Fig. 1. Specimen in the Los Angeles Museum at Exposition Park.

TRAUMA AS AN IMPORTANT FACTOR IN LUXATIONS

I believe injuries, often of a violent nature, to have been the most important and underlying factor in all of the Pleistocene luxations discussed in this paper. The presence, almost uniformly, of eburnated surfaces in Pleistocene luxations, is an indication that the membrane of the joint has been disturbed by external violence. Trauma underlies all of the dislocations, both partial and complete. In the case of the tiger pelvis (Fig. 9) the violence was followed by a severe infection, which involved not only the hip-joint but all the surrounding areas. The life these mammals led in those far-off Pleistocene days was one of rapine and constant alertness was necessary to avoid injury and death. The wonder is that more luxations are not seen, but an animal with a crippling luxation would be severely handicapped.

MODERN, BILATERAL LUXATIONS IN A KANGAROO

A skeleton of an adult kangaroo in the Los Angeles Museum shows in the femora and pelves disturbances which may have followed from sepsis. The animal was said to have been captured in Australia as an adult, and became an inmate of one of the zoological gardens of the city. There is no clinical history and we know only the end-results in the skeleton. No other parts of the body show any pathological changes.

Both hips show exaggerated luxations with loss of heads and necks of the femora (Fig. 5, A and B). The conditions are quite similar to that described for the wolf (Fig. 2B and C). The articular area measures 25 mm. × 70 mm. and unlike the wolf shows an area near the middle of intense eburnation. The ivory-like bone is more extensive on the pelves, where the acetabulum has been filled with excess callus. Numerous openings in both femora and pelves doubtless are necrotic sinuses. The acetabular area measures 43 mm. × 50 mm., fully one-half of which is eburnated.

Roentgenograms of a femora and the acetabular part of the pelvis are shown in Figure 6, A and B. The architecture is clearly distorted, showing a condition of long-standing.

There are no changes in the articular surfaces of the lower ends of the femora.

A PLEISTOCENE PSEUDARTHROSIS

The identification of the fragment of bone shown in Figure 7 is in considerable doubt. I believe it to be a part of the femur of a giant wolf, but it is so changed by the excess callus on which the new articular surface was developed that I cannot be sure. A short time ago I identified as a wolf femur a fragment of a sabre-tooth rib which was so greatly changed by disease as to be almost impossible to identify.

This example of a pseudarthrosis is unique among the Pletisocene mammalia of the Rancho la Brea. Its description in this place is justified because its condition indicates an ankylosed hip. The length of the fragment is 120 mm. with a thickness of 58 mm. through the callus. The diameter of the shaft is 20 mm.

The upper surface of the callus (Fig. 7) is greatly eburnated, though not so highly polished as other eburnated surfaces I have seen. The eburnated area is saddle-shaped, measuring 30 mm. × 35 mm. Around its edges roughened bone suggests an intense preceding infection. I believe the bone to have been fractured immediately below the anatomical neck, but extracapsular.

The roentgenogram shows the bone immediately below the eburnated area to be quite dense.

A TRAUMATIC LUXATION

The wolf femur (Fig. 2, D and E) showing the effects of a traumatic dislocation is complete, measuring 256 mm. Careful measurements of several hundred femora of *Aenocyon* show ranges in length of from 230 mm. to 270 mm., so the present example is a little above the average. The torsional angle is 8+°.

There is no way of explaining just how

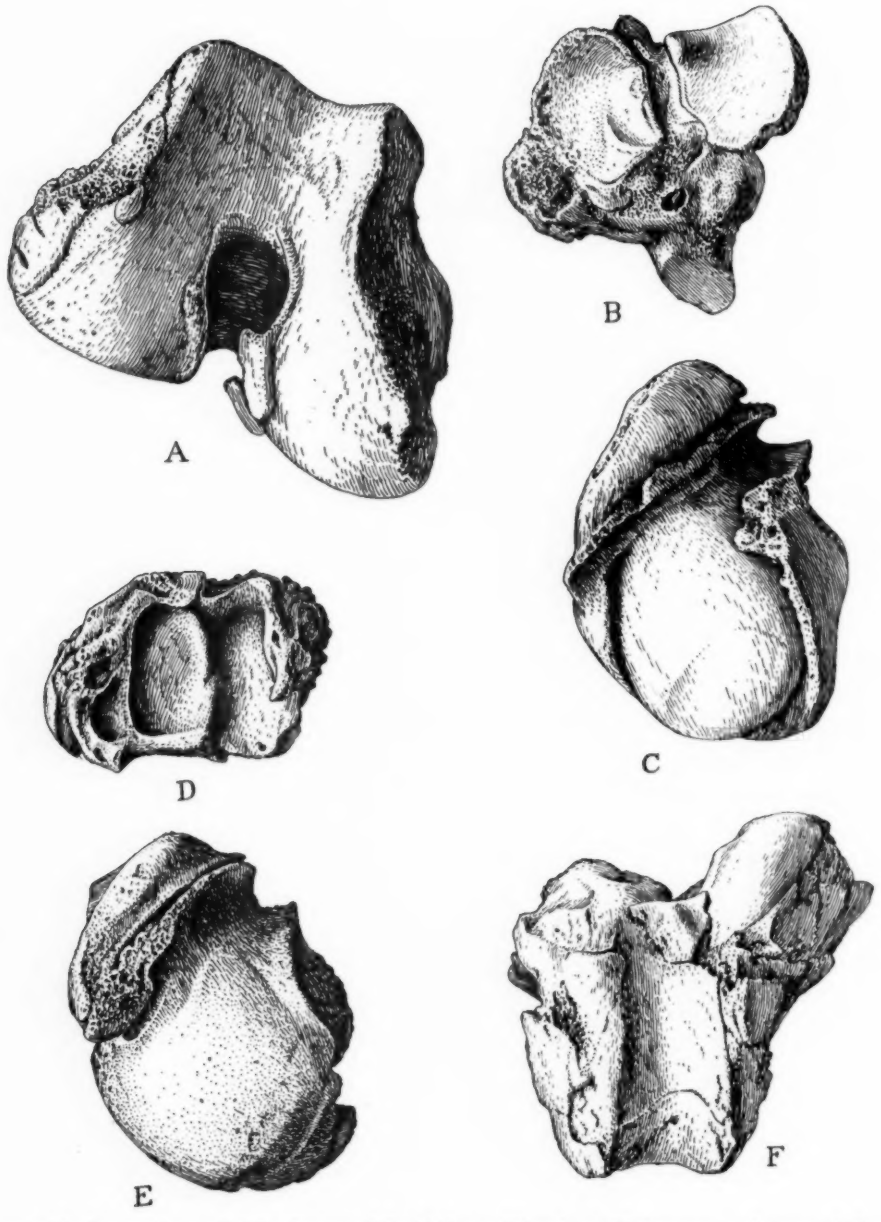


FIG. 10. A: Lower articular surface of right femur of *Smilodon californicus*, Pleistocene sabre-tooth from the Rancho la Brea, showing reduction of articular area by peripheral exostoses. Posteriorly articulating surfaces are eburnated for distance of 50 mm. Area here shown had not been in use for some time before the death of the animal thus forming an example of partial or incomplete luxation. Marginal lipping, posteriorly, more pronounced on right side of the bone and associated with disturbance in the popliteal space, above which on the right there is a large exostosis. Greatest diameter of surface depicted 85 mm.

B: Upper articular surface of tibia of giant wolf, *Aenocyon dirus*, showing arthritic disturbances involved in partial luxation. Peripheral lipping more pronounced on left in drawing due to injury represented by the large exostosis. Area shown has diameter of 52 mm.

C: Upper articular surface of humerus of giant wolf showing almost complete luxation brought about by extravagant growth of periarthritic lesions. Lips of bicipital groove ossified for considerable distance down anterior surface. Oval area, shown in drawing, had been the only functioning articular surface for some time. Area is eburnated and worn almost flat. Associated scapula has been identified, and is shown in Fig. 11, upper figure. Oval area has long diameter of 30 mm.

D: Lower articular surfaces of pathologically coossified tibia and fibula of giant wolf. Joint highly diseased and articulating surfaces deepened, eburnated and worn. Transverse diameter of surface shown is 54 mm.

E: Upper articular surface of humerus of giant wolf which had been fractured and in which severe osteomyelitis had developed (see *Ann. M. Hist.*, 8: 416, 1926). Disturbannces in articulation due to necessity brought about by newly established angle of torsion. Area is restricted, eburnated and imperfect, a partial luxation. Entire bone much shortened, having length of 180 mm., as compared with a length of 227 mm. of normal bone.

F: Lower articular surface of incomplete femur of giant wolf. Partial luxation indicated by destruction of condyle on the left. Surface on right was only one functioning and that was rendered imperfect by arthritic lesions which had crept in from the sides. Numerous lesions about and above joint surface indicate an intense infection due to injury which involved destruction of condyle. Joint surface very imperfect.

this dislocation took place, but the life of a wild carnivore must have been replete with scenes of violence. The present individual was more fortunate than others, and was able to survive its crippled state by actively, though painfully, evading his enemies. After the pain had subsided and the pseudarthrosis formed, the animal was doubtless as easily agile as others.

The eburnated area on this male wolf femur covers an area 25 mm. wide by 55 mm. long, including a slight area on the lower part of the head, and extending well down onto the body of the diaphysis. The head itself as shown in Figure 2D has an acuminate cap of new bone below which there is other new growth of bone. The growth of excess callus on the femur is greater than that shown in the pelvis.

There is no change in the articular surfaces of the lower end.

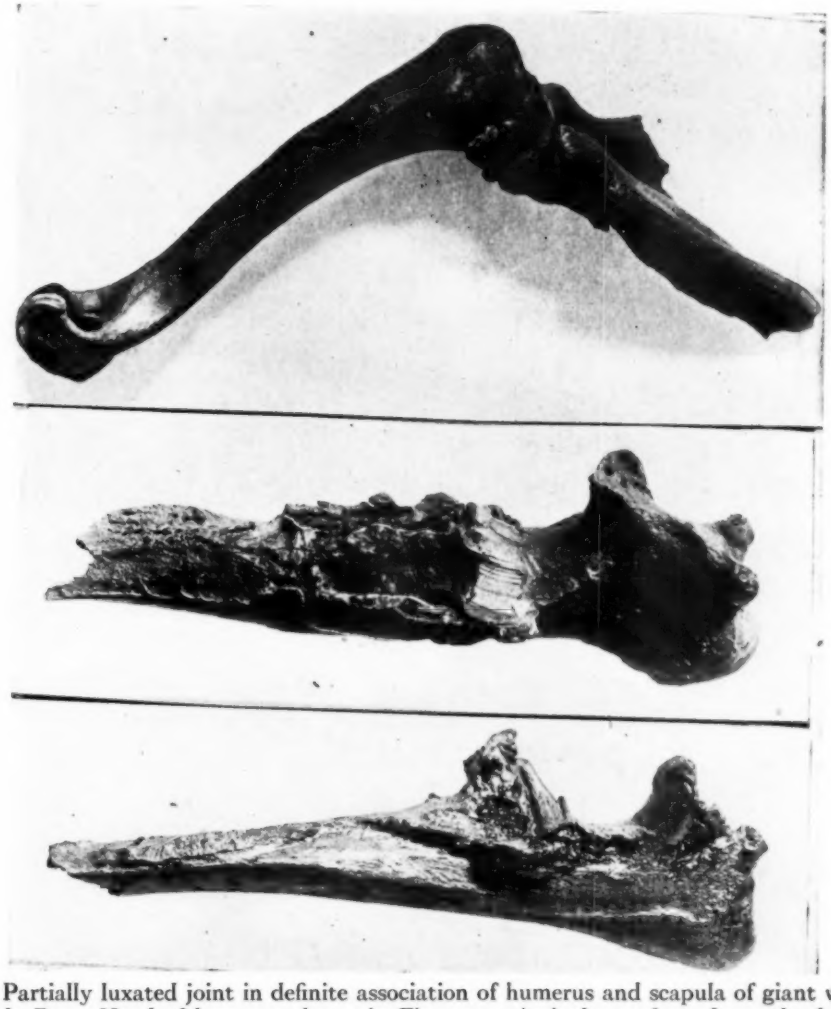


Fig. 11. *Upper:* Partially luxated joint in definite association of humerus and scapula of giant wolf, Pleistocene of the Rancho la Brea. Head of humerus shown in Fig. 10, C. Articular surface of scapula shows overlapping peripheral exostosis destroying serviceability of joint. Articulation confined to sharply marked crescentic area, highly eburnated, on inner margin of fossa. This surface articulates with oval, flattened area shown in Fig. 10, C.

Middle: Eburnated striae in articular surface of ulna of Pleistocene wolf, with associated pathological lesions due to injury. Wolf bones show great variety of arthritic disturbances, much more than any other species, and they will be discussed and figured in another contribution. Length of bone, 140 mm. Effect is that of partial luxation.

Lower: Partial luxation in articular fossa of wolf ulna. Original joint surface partly buried by overlapping exostoses and it is on these that the humerus articulated. Origin of lesions may be traced to injury to olecranon. Length of bone (incomplete), 142 mm. Specimens in Collections of Los Angeles Museum at Exposition Park.

PLEISTOCENE WOLF PELVIS SHOWING EFFECTS OF LUXATION

I have the good fortune to have studied a femur (Fig. 2, D and E) and a pelvis (Fig.

FIG. 12. Large pool or pit at the Rancho la Brea on Wilshire Boulevard, Los Angeles, as it appeared twenty years ago. It has not changed perceptibly since. This pit made originally for asphalt for road building and bones of Pleistocene mammals were cast aside. Further excavations subsequent to 1906 resulted in recovery of much material. When I visited the locality in 1909 elephant bones were being extracted from bank to right of *b*. The entire area, something over 30 acres, has been given by the owners to the county as a Pleistocene Park, under the direction of the Los Angeles Museum.

a: Water and oil cover floor of pit to undetermined depth. Gas bubbles may be seen breaking surface in background on right.

b: Asphalt seen at east end of pit. Tar fairly soft and viscid. It forms a most wonderful trap for unwary animals, giving an insight as to how Pleistocene mammals were caught.

4) of a giant wolf which definitely match, though found separate.

As shown in Figure 4 the acetabulum is

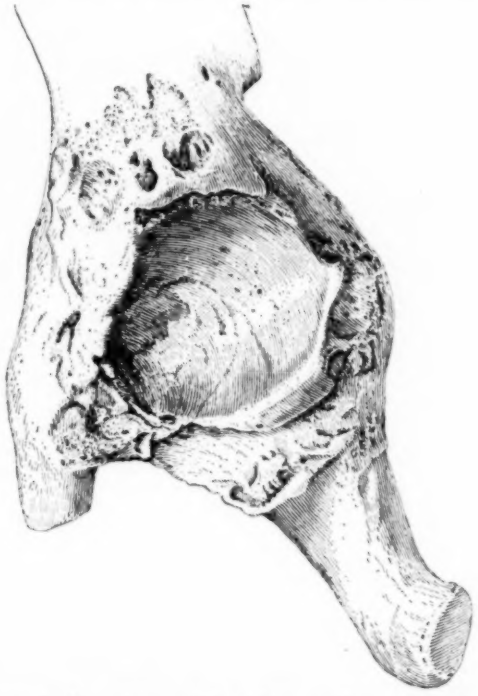


Fig. 13. Left ramus, adult sabre-tooth pelvis, Rancho la Brea, showing great roughening and thickening in area about acetabulum, due to infected injury, and resulting in partial luxation of hip. Normal acetabulum practically circular, measuring about 50 mm. in diameter, but this acetabulum has area of 55 mm. x 70 mm., and is quite shallow, while normal acetabulum is quite deep. Upper (to right) one-half of articular area functional, and highly eburnated, with maximum diameter of 30 mm.

Entire length of pelvic ramus 30.5 cm. Los Angeles Museum of History, Science and Art, Exposition Park.

completely destroyed and filled in with excess callus. On this excess callus is an eburnated area, 25 mm. x 45 mm., saddle-shaped, on which the neck of the femur (Fig. 2, D and E) articulated. As in the case of the pseudarthrosis (see Fig. 7) the margins of the eburnated area are beset with greatly roughened bone. The head of the femur also shows changes.

The pelvis (Fig. 4) is fragmentary, measuring 160 mm., as compared with a measurement of 225 mm. for the complete bone.

Another example of complete luxation is to be found in the pelvic bone of the giant wolf in which the acetabulum is reduced from the normal by 3 mm. in diameter, with an enormous amount of callus, roughened by numerous exostoses and

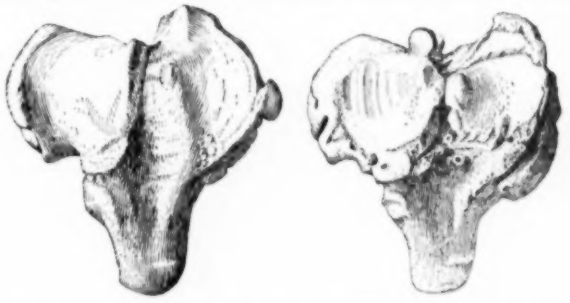


Fig. 14. Luxation in tibia of a coyote, Rancho la Brea.

Left: Articular area only slightly reduced by marginal osteophytic growths. x 1.

Right: Right tibia of Pleistocene coyote, Rancho la Brea. Articular surfaces greatly reduced, to area of 10 mm. on one side, to the right, and to area of 7 mm. on the other. This small area highly eburnated with series of parallel striae. Marginal osteophytes very pronounced, indicating arthritic disturbance of some severity. x 1. Los Angeles Museum of History, Science and Art, Esposition Park.

necrotic sinuses. The acetabulum shows no sign of wear, and an area on the upper side measuring 15 × 42 mm. shows eburnation as if the neck of the femur had articulated on this surface, in this case leaving the acetabulum without much change.

AN UNUSUAL PATHOLOGICAL CONDITION

The following is an unusual pathological condition in the pelvis of a sabre-tooth regarded as due to infection, following a violent trauma, which also resulted in luxation.

The sabre-tooth pelvis, shown in Figures 1 and 9, is the most strikingly pathological object in the collection of Rancho la Brea fossils, preserved in the Los Angeles Museum. The infection, following trauma, confined its ravages to the right pelvic ramus. The acetabulum of the diseased side measures 85 mm. in diameter, as compared with a diameter of 48 mm. in the normal side (see Fig. 1).

The pelvis is probably that of an adult male, and the injury may have been received in an encounter with another sabre-tooth. The entire acetabular region resembles in its appearance that of a lava bed. The several vesicular pockets, measuring 17 mm. in depth and 36 mm. in

length, recall black lava bubbles. The numerous osteophytic growths are largely rounded near the acetabulum, but out on the ilium they are fenestrated and spinous. The articular surface for the head of the femur is restricted to an eburnated area in the dorsal portion of the acetabulum (Fig. 9). The bone forming the bottom of the acetabulum is of paper-like thinness, and although broken in the specimen during collection, it was doubtless complete during the life of the animal. The dorsal aspect of the acetabular region presents a thickness of 44 mm. as compared with 28 mm. of the normal side. This surface is covered with ramifying vascular channels and foramina, recalling in appearance the surface features of an osteosarcoma in an ancient Egyptian pelvis, described by Ruffer. Like that specimen, too, the tiger pelvis presents a pubic thickness which may well represent a tumor, but I think from the general aspect of the bones that all of lesions were due to infection, following trauma, and are not neoplastic.

The pelvis was isolated and no associated bones, such as the sacrum and femur, have been identified in the collections. Although I have examined individually all of the 1945 femora of the sabre-tooth, contained in sixty museum trays, during a count to determine the incidence of disease (1.64 per cent) I found no trace of a femur showing characters such as would be demanded by the articulation with this disturbed acetabulum. The femora present evidences of fracture,[1] pressure atrophy,[1] arthritis deformans,[3] slight subperiosteal exostoses,[10] and partial luxation of the lower end,[1] but not an upper luxation. I made no effort to try to match any of the 1046 sacra with this pelvis.

A luxation in a tiger pelvis, without infection, is shown in Figure 13. The acetabulum is extremely shallow and the luxation seems to have been of long standing.

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BOOK REVIEWS

Radiographie Nephro-cholecystique. By Dr. Manuel de Abreu, Brazilian Inst. of Sciences & Acad. of Med. Rio de Janerio. 158 pp. 54 cuts, & 54 drawings. Paris, Masson & Cie, 1930.

The reader finds this a very interesting work on the radiographic diagnosis of gall-bladder and renal disease, especially with reference to the differential diagnosis. The differential diagnosis of abdominal concretions is often complicated, particularly gall-bladder and renal calculi. The author has studied very carefully the various angles of incidence, anterior, posterior, oblique and combined; and has estimated the volume and shape of the kidney in these various positions. He has made a careful comparison of vesicular and renal shadows, especially after turning the patient in the oblique position so that the zone of the renal pelvis is thrown far away from the shadow of the gall-bladder region. The author calls attention to the advantage of pyelography in the Trendelenburg position, the renal pelvis and the calyces being demonstrated more easily in this position, and recommends renal

radiography in the oblique incidence when there is doubt as to the findings in the classical anteroposterior position. The value of the book is greatly enhanced by the beautiful collection of roentgenograms.

Etudes Radiologiques sur le Poumon et le Mediastin, Radiologie Vasculaire—Aorte. [Radiological Studies of the Lung and Mediastinum, Vascular and Aortic Radiology.] By Manuel de Abreu, Brazilian Inst. Sciences & Acad. of Med., Rio de Janerio. 200 pp. 42 tables, 79 figs. Paris, Masson, 1930.

This work is characterized by the originality of the author's views and the interest one must take in his personal researches concerning the aorta and the heart. Considerable discussion has been aroused in France by the publications of Dr. Abreu, and it is gratifying to see this abundantly illustrated publication setting forth his latest views.

The first chapter concerns the evaluation of the relative volume of pulmonary lesions; the second chapter discusses the various discrete forms of pulmonary tuberculosis as seen in the roentgenogram; the third concerns roentgenometry of the mediastinum; and the fourth is a critical discussion and interpretation of the classical findings of vascular radiology, followed by certain new signs which the author has developed.

Radiologie Clinique du Tube Digestif. [Clinical Radiology of the Digestive Tube.] By J. Gatellier, Assist. Prof. Fac. Med. Paris; F. Moutier, Chief, Lab. Fac. Med. Paris, and P. Porcher, Chief, Dept. Radiol. Fac. Med. Paris. Publ. under direction of M. Pierre Duval, J. Ch. Roux, and Henri Béclère. Vol. 2, 390 pp., 417 roentgenograms & 407 schematic drawings. Paris, Masson et Cie, 1930.

The first volume of the series appeared in January, 1928, and in spite of a rather large edition the book soon was out of print. The presentation and the method of explanation of this second volume are identical with that of the first. The same rules that were followed in the volumes on the Stomach and Duodenum have been adhered to rigorously with reference to the execution of the present work. This is not simply an album of choice roentgenograms with simple legends. All of the illustrations have been carefully chosen because of their utility in demonstrating important lesions of clinical radiology, and the text constitutes a running commentary of the facts which justify the diagnosis, illustrated by roentgenograms. Each roentgenogram is accompanied by a carefully made outline drawing, with the indications of the various anatomical points. The book constitutes a valuable collection of diagnoses, carefully discussed and proven, including the pathology of the esophagus, the intestine, the pancreas, the spleen, the liver and the salivary glands. Each of the diagnoses is established both by clinical and radiological evidence, and is confirmed by operative intervention.

The publishers have aided very satisfactorily with the production of the book, which constitutes a volume of which the radiological profession, both in France and in this country, may well be proud.

A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM

EDWARD M. LIVINGSTON, M.D.

PUBLISHED SERIALLY IN

The American Journal of Surgery

EIGHTH INSTALLMENT CONTENTS

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A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM

Section II. The Gastrointestinal Tract

A. Basic embryological considerations (*Continued*)*

4. Final Attachments of the Gastrointestinal Tract (*Continued*).

c. Attachments of Stomach. Peritoneal folds pass from the stomach to the liver, transverse colon, spleen, biliary ducts, diaphragm and pancreas. The structure of these folds is indicated by their several names (gastric ligaments, omenta, epipla). They are termed ligaments because of the support which they provide (L. *ligamentum*, a band or bandage); omenta, because rich in fats (Gr. *omentum*, a fatty membrane); and epipla, because compound in character (Gr. *epi*, upon + a double fold). The words epiploic and omental are, then, synonymous (see epiplocele, epiplomphalocele, epiplopexy).

Terminology

The two broad surfaces of the stomach, an anterior belonging to the general peritoneal cavity and a posterior belonging to the lesser cavity or omental bursa, are free and unattached, for gastric attachments are found only along the curvatures (Fig. 120 A & B). The postnatal stomach, in contrast to the embryological organ, has no direct connections with the abdominal walls but is joined to the parietes only indirectly or by way of intervening viscera. Omenta are, in fact, defined as compound peritoneal folds which pass from the stomach to other intra-abdominal organs. This final arrangement represents a marked change from the earliest conditions in which the developing stomach is attached to the anterior abdominal wall by an anterior mesentery and to the posterior wall by a posterior mesentery.

* Previous installments of this book appeared as follows: vol. 8, January issue, p. 193; February issue, p. 459; March issue, p. 693; April issue, p. 92; May issue, p. 1110; June issue, p. 1325; vol. 9, July issue, p. 157.

All ligaments and omenta of the adult stomach originate, however, from the simple midline mesenteries of embryonic life Fig. 121. And the logical manner in which to gain a clear

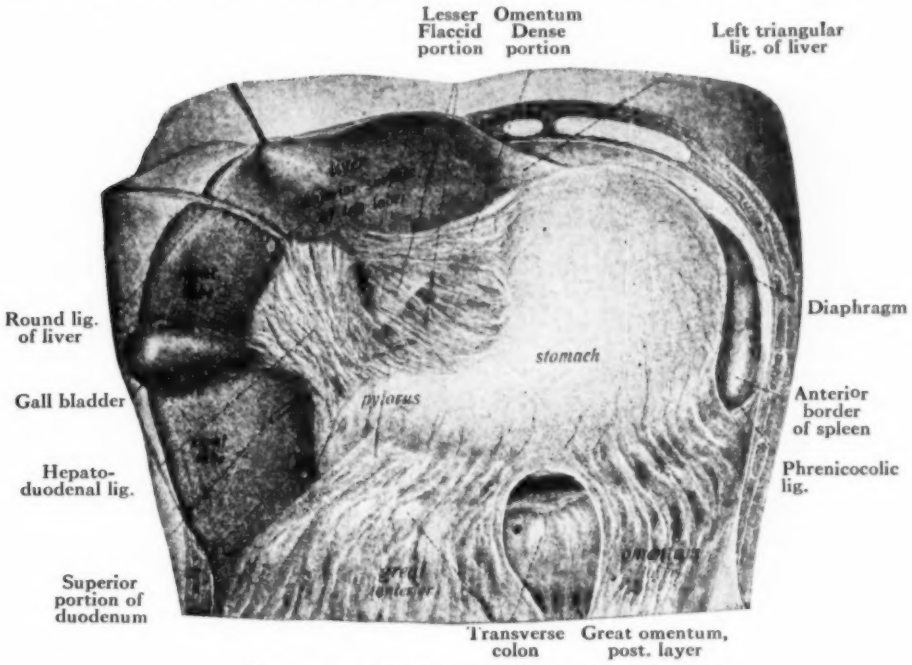


FIG. 120A. Attachments of the stomach.

A. Anterior view. (From Sobotta).

comprehension of the ultimate, complex connections of this organ is through a visualization of succeeding steps or stages in gastric development.

Origin of Lesser Omentum

The manner in which stomach becomes connected with liver is as follows: the bulk of the liver (mesodermal portion) develops within the anterior mesentery (see septum transversum and its derivatives; p. 17); hence this large digestive gland becomes interposed between stomach and anterior abdominal wall so that the stomach no longer appears connected with parietes but with liver (See Fig. 121). The connecting double peritoneal fold is appropriately termed the *lesser* omentum (ligamentum hepatogastricum) thus reserving the name *greater* omentum for that larger fatty sheet which passes between stomach and transverse colon (ligamentum

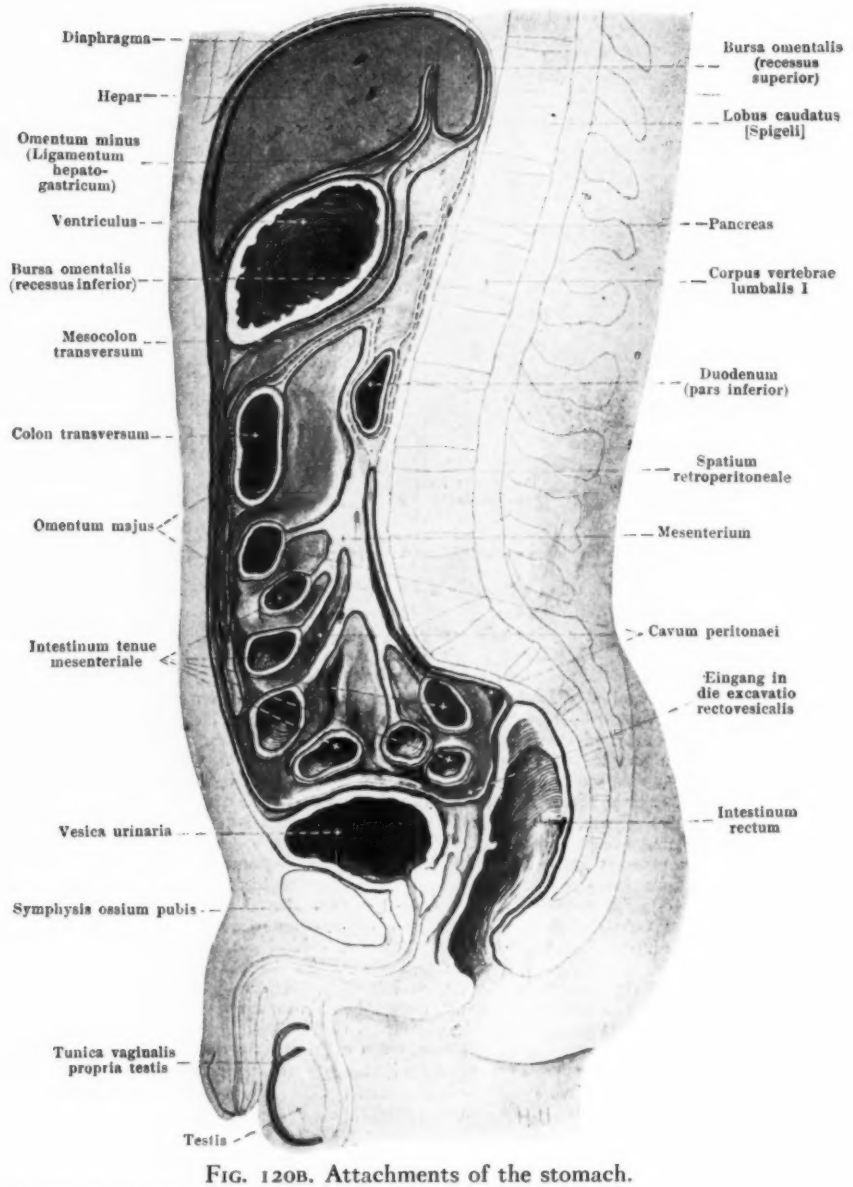


FIG. 120B. Attachments of the stomach.

B. Longitudinal section. (From Spalteholz.)

gastrocolicum) then continues downward in front of the intestinal loops as a large caul, veil or apron. The gastrohepatic or lesser omentum extends from the entire lesser curvature of the

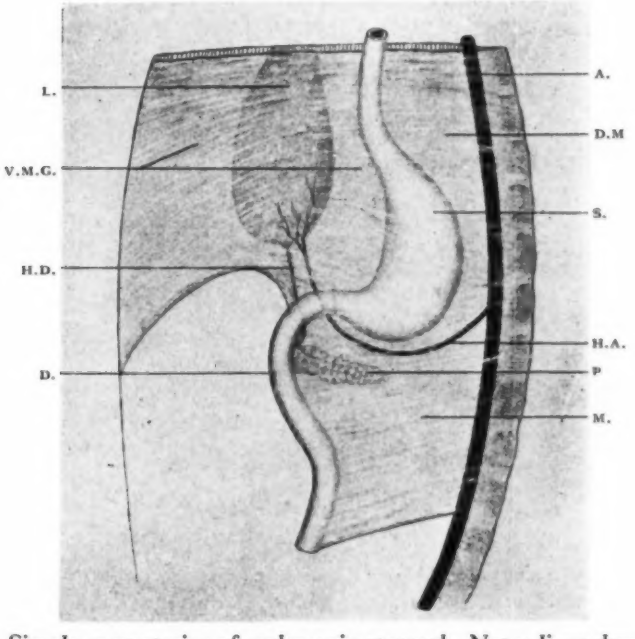


FIG. 121. Simple mesenteries of embryonic stomach. Note: liver develops between stomach and anterior body wall changing attachment of stomach. Observe association of hepatic artery and duct near free border of ventral mesentery. This arrangement is important with reference to the formation of foramen of Winslow. The liver divides the ventral mesogastrium into a dorsal segment, the gastrohepatic or lesser omentum, and a ventral segment, the suspensory or falciform ligament of the liver. (From Huntington.)

L, liver. V.M.G., ventral mesogastrium. H.D., hepatic duct. D, duodenum. A, aorta. D.M. dorsal mesogastrium. S, stomach. H.A., hepatic artery. P. pancreas. M. mesoduodenum.

stomach to the under surface of the liver (transverse fissure or porta hepatis). Specific details regarding its portal attachments will be discussed with the study of the liver (Section IV) and the peritoneal bands known as ligamenta variata (Section V).

As shown by the researches of Winslow (see eponym) the peritoneal coverings of the omenta are continuous with those of the stomach. This investigator, inserting a quill beneath peritoneal surfaces at various points, ascertained their exact reflections by observing the manner in which air he introduced

through the hollow instrument insinuated itself through subperitoneal tissues.[155] And the lesser omentum, it was ascertained, like the stomach, possesses two free surfaces, of which

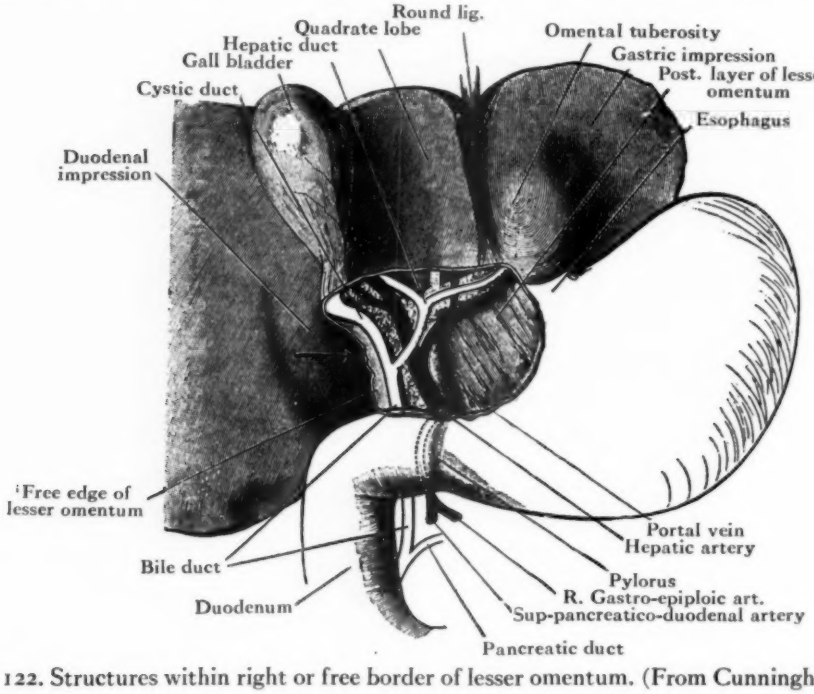


FIG. 122. Structures within right or free border of lesser omentum. (From Cunningham.)

Researches of Winslow

one is related to the general peritoneal cavity and the other to the omental bursa (see Fig. 120). Between the omental layers are found fat, vessels, areolar tissue, nerves, lymph nodes (see primary germ layers, p. 281 and intra-abdominal neoplasms, p. 279).

Between the peritoneal reflections a narrow sheet of extraperitoneal tissue connects stomach and liver (see Fig. 120). Because of this, it is possible for a sharp foreign body to penetrate stomach wall, work its way between the leaves of the lesser or gastrohepatic omentum to reach and penetrate the liver and there set up an inflammatory reaction or give rise to an hepatic abscess, without causing any invasion of the general peritoneal cavity. Treves has thus explained the finding of sharp bones or toothpicks within liver abscesses.[156] A similar

Extraperitoneal Pathways

invasion, without concomitant involvement of the general peritoneal cavity, of the extraperitoneal pathways found between the peritoneal surfaces, has previously been noted in describing cases reported by Osler, [157] in which abscesses confined within the falciform ligament of the liver were drained by way of the anterior abdominal wall without a resulting general peritonitis (p. 12). Such unusual cases serve not only to bring to mind these possibilities but also aid materially in effecting the visualization of anatomical relationships.

Within the free margin of the lesser omentum (right border or hepatoduodenal portion) are situated the following important structures, named from right to left; (a), the common bile duct, (b), the portal vein (c), the hepatic artery, (D: V: A; duct: vein: artery) together with lymphatics and nerves. The vein lies posterior to the artery and duct and between them. (Fig. 122, also Fig. 125.) This arrangement has both definite advantages and disadvantages for the surgeon. It is advantageous in that the common bile duct may readily be found and palpated within this free omental border and the common duct; coursing along this extreme free margin, may be incised if necessary, as for the liberation of a common duct stone, without great danger to hepatic artery or portal vein which lie further to the left. It is disadvantageous, however, in cases of herniation through the foramen epiploicum, for the free margin of the lesser omentum forms the anterior boundary of this opening (Winslow's foramen); here herniated bowel may be incarcerated at the orifice, yet the operator be unable to liberate the gut by cutting the most accessible part of the constriction (free border of lesser omentum). Should this right border of the omentum be cut through, the common bile duct would certainly be severed and a risk taken of causing irreparable damage to the hepatic artery or portal vein. This condition in which distended intestinal loops cannot be mechanically withdrawn from the omental bursa into which they have passed, may be dealt with by the method previously described of first incising and emptying the bowel by means of a suction tube

Palpating the Common Bile Duct

Releasing Bowel Herniated through the Foramen Epiploicum

(Fig. 117). The immediate collapse of the intestinal loops which follows this withdrawal of the enteral contents renders reduction of the internal hernia by simple traction an easy

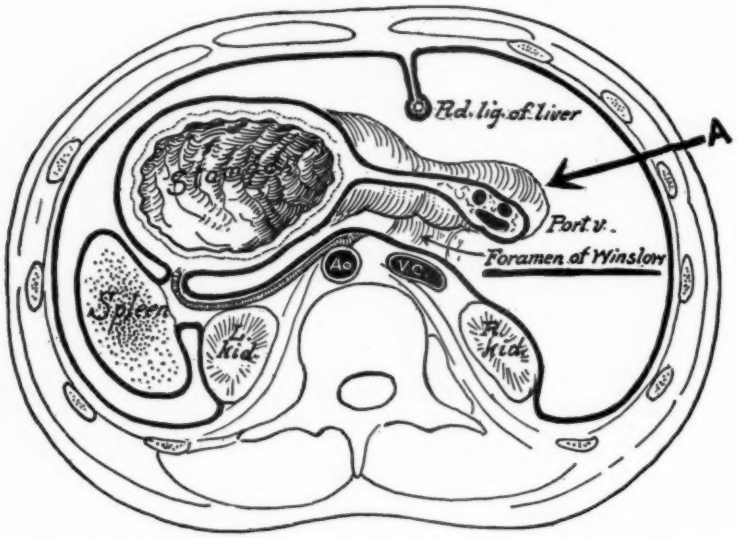


FIG. 123. Cross section of abdomen at level of foramen epiploicum. Note relationship of structures in free border of lesser omentum (A) (duct, vein, artery) to the foramen of Winslow. (From Hertzler's The Peritoneum, Mosby.)

and successful maneuver and one which may be accomplished without endangering important structures at the point of obstruction.

Origin of the Foramen of Winslow

The foramen of Winslow (foramen epiploicum), as described in the words of the anatomist in whose honor it is named, is considered in an accompanying eponymic study (pp. 263–267). This important narrow point of constriction within the peritoneal cavity is produced largely by the hepatic artery as it passes upward from its retroperitoneal origin from the celiac axis,[158] taking the shortest course to reach the liver, thereby throwing the overlying peritoneum into an elevation or ridge. The constriction is increased by the portal vein as it courses upward from below the pancreas to reach the liver by way of the lesser omentum. The manner in which artery aids in the formation of the foramen of Winslow, after the stomach has undergone rotation and as the first portion of the duodenum

has become fixed or partially retroperitoneal, will be reviewed subsequently with a study of the vascular supply of the enteric canal and its derivatives. Suffice it to state that as the artery

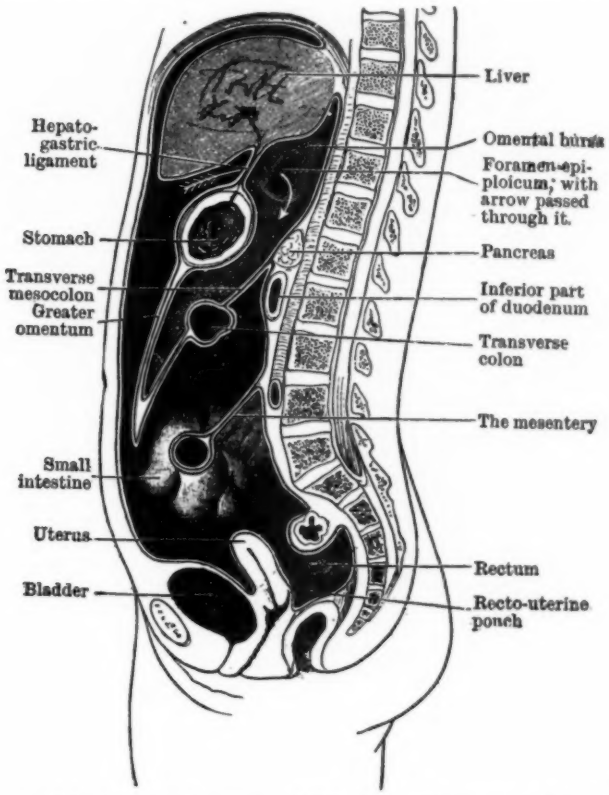


FIG. 124. Omental bursa and foramen of Winslow. Diagrammatic median section of female body, to show the peritoneum on vertical tracing. The great sac of the peritoneum is black and is represented as being much larger than in nature; the bursa omentalis is very darkly shaded; the peritoneum on section is shown as a white line; and a white arrow is passed through the foramen epiploicum from the great sac into the bursa omentalis. (From Cunningham.)

leaves the retroperitoneal tissues to traverse the free border of the lesser omentum and reach the liver at the porta hepatis, the peritoneum is thrown into an hour-glass constriction so tight as to allow only the finger (index) to pass between the artery anteriorly (free margin of lesser omentum) and the posterior abdominal wall posteriorly (parietal peritoneum) (Fig. 123). The foramen represents, in a word, a space or semi-

lunar opening below the margin of the original ventral mesogastrium. It must be apparent that some such foramen or cleft leading into a retrogastric space is an inevitable accompani-

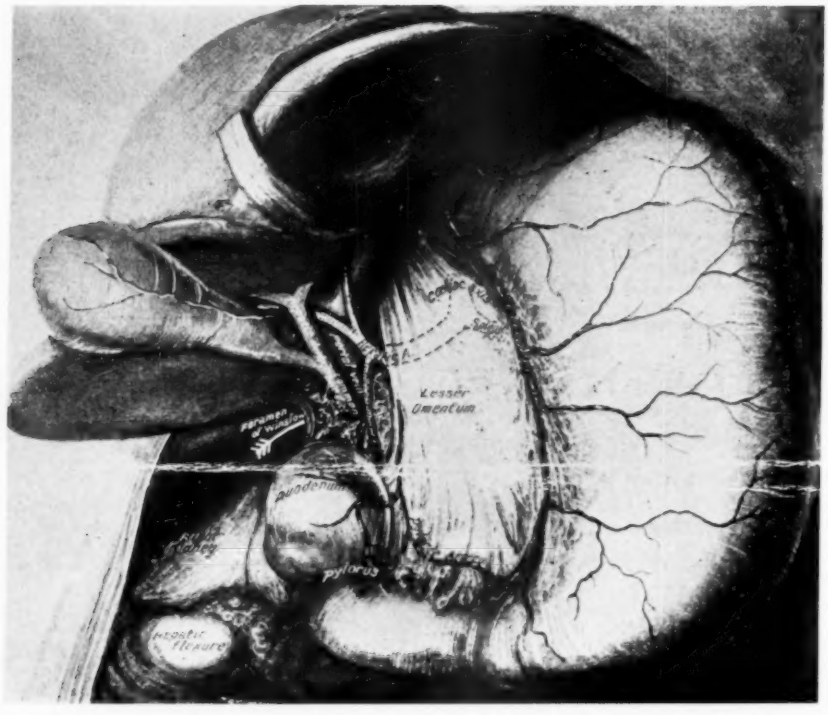


FIG. 125. Foramen of Winslow. The deep relations of the liver and the chief structures in relation to the common bile duct. The right and left hepatic ducts unite to form the hepatic duct proper, and this is joined lower down by the cystic duct, the junction of these two forming the common bile duct. This latter is seen in its supraduodenal stage in front of the foramen of Winslow. (From Taylor's Operative Surgery, Wood.)

ment of the rotation of the stomach and subsequent fixation of the duodenum (the lowest point in the gastrointestinal tract supplied with a ventral mesentery); (see Fig. 121) but it is the hepatic artery, taking the shortest course from its fixed retroperitoneal point near the adherent duodenum to reach the liver by traversing the margin of the gastrohepatic omentum, which determines the fact that the foramen is of such small caliber.

Because of this constriction (foramen epiploicum) the peritoneal cavity seems to consist of two compartments

(greater and lesser sacs) (Fig. 124) whereas in reality the peritoneal membrane forms but a single cavity and this narrow point (foramen of Winslow) is simply a secondary developmental arrangement. To find this foramen the surgeon must invade the supracolic division of the peritoneal cavity, lifting forward the right lobe of the liver and depressing the stomach. The palpating finger is passed along the posterior parietal peritoneum immediately above the proximal or first portion of the duodenum until the finger tip has passed below the free border of the lesser omentum (Fig. 125). The relationship of the examining finger to surrounding structures is then as follows:

Locating and Palpating the Foramen Epiploicum

In front (anteriorly) lies the right border of the lesser or gastrohepatic omentum (ligamentum hepatogastricum) containing, from right to left, the ductus communis choledochus, the portal vein and the hepatic artery.

Behind (posteriorly) lies the inferior vena cava and the right crus of the diaphragm, covered by the posterior parietal layer of peritoneum.

Above (superiorly) is located the caudate lobe of the liver.

Below (inferiorly) is situated the duodenum and the part of the hepatic artery proximal to its entrance into the free margin of the lesser omentum.

The retrogastric space, omental bursa, lesser peritoneal sac, Winslow's pouch and cavity of the omenta, all are terms applied to the cavity existing behind the stomach and reached through the foramen epiploicum just described. This peritoneal pocket with its peculiar narrow point of connection with the remainder of the peritoneal cavity is developed as follows: as the stomach rotates, its dorsal mesogastrium, which originally stretched firmly from the posterior gastric wall (developing greater curvature) to the midline of the posterior abdominal wall, necessarily must become relaxed or elongated to allow the rotation to take place; and when the gastric fundus reaches its final position to the left of the midline it is obvious that a pouch must exist behind this viscus, and that

Formation of the Omental Bursa

this pouch must be closed from the general peritoneal cavity above, below and to the left, but open into it on the right side Fig. 126. The omental bursa into which, as stated, the tip of the

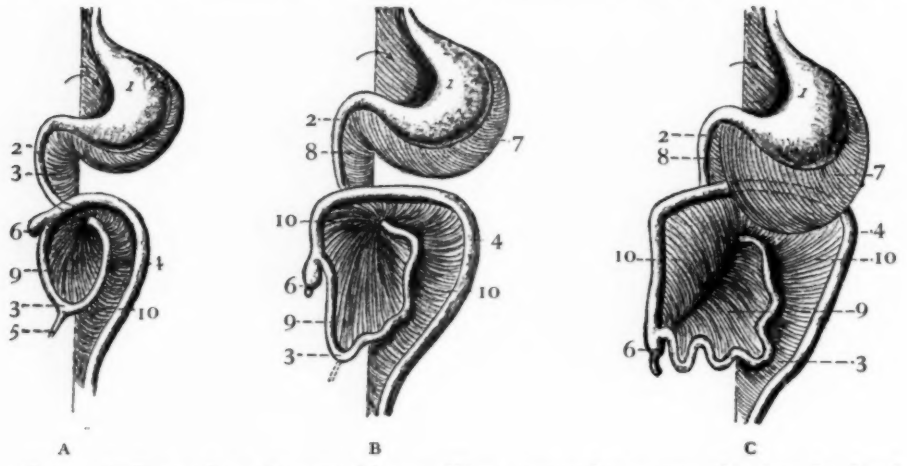


FIG. 126. Formation of omental bursa. Three successive stages, showing the development of the digestive tube and the mesenteries in the human fetus. (Modified from Tourneux.)

1, stomach, 2, duodenum; 3, small intestine; 4, colon; 5, vitelline duct; 6, cecum; 7, great omentum; 8, mesoduodenum; 9, mesentery; 10, mesocolon. Arrow points to the orifice of the omental bursa. The ventral mesentery is not shown (Heisler). (From Prentiss' Textbook of Embryology, Saunders.)

examining finger passes when it is inserted into the foramen of Winslow is in reality a pocketing of the right half of the upper portion of the peritoneal cavity as the stomach undergoes rotation.

Various routes by which the omental bursa may be invaded (by infections, by foreign bodies, by the surgeon) are shown graphically in the accompanying Figure 127 A–C. Surgical drainage (for perforations of the posterior gastric wall, pancreatitis, bullet wounds) has been discussed on p. 152; drainage is most often effected by way of the lesser omentum or through the gastrocolic ligament, less often by way of the transverse mesocolon, and occasionally through the posterior abdominal wall; the latter method is employed only in instances in which a foreign body has invaded the bursa by this pathway (see bullet wounds of stomach and pancreas).

Contamination and Drainage of the Retrogastric Space

Whatever route is chosen for draining this lesser peritoneal sac it seems logical also to place a prophylactic wick or drain into

the subhepatic space (Morison's space) inasmuch as excess fluid from the omental bursa spontaneously invades this region, passing through the foramen of Winslow. With the patient on

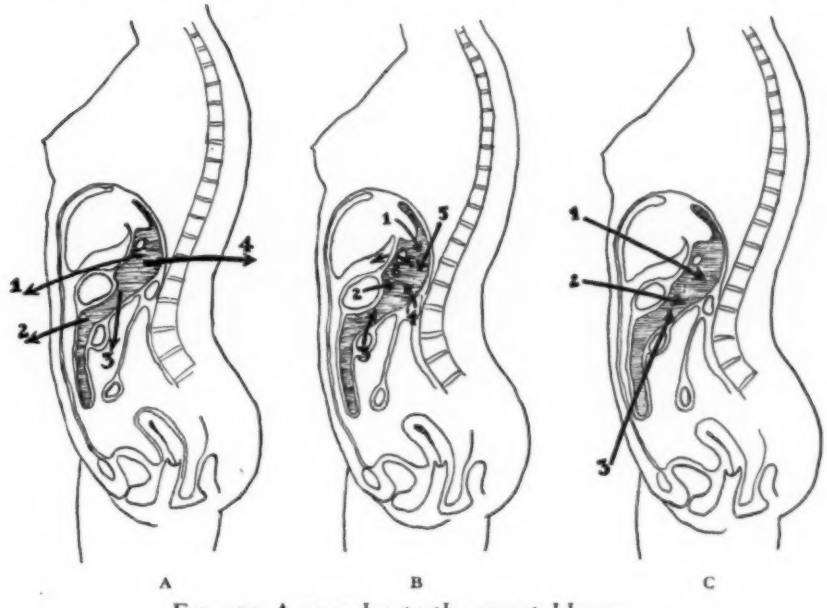


FIG. 127. Approaches to the omental bursa.

A. Surgical drainage: (1) through lesser omentum; (2) through gastro-colic ligament; (3) through transverse mesocolon; (4) through posterior abdominal wall.

B. Direct contaminations (infections): (1) from liver; (2) from stomach; (3) from colon; (4) from pancreas; (5) from thorax; (6) drainage through foramen of Winslow.

C. Gunshot wounds: 1–3 illustrate how penetrating foreign bodies may invade omental bursa after passing through other structures.

the right side this drainage out of the bursa by way of the epiploic foramen is a natural or gravity outflow. Contamination of the subhepatic space seems so inevitable that drainage by other routes alone would appear scarcely complete. A prophylactic wick in the subhepatic space could do little harm and might prove the means of preventing widespread contamination of the general peritoneal cavity.

The elongation and relaxation of the primitive dorsal mesogastrium does not cease with the completion of the rotation of the stomach but continues until a broad sheet of peritoneum (floor of omental bursa) hangs down from the greater curvature of the stomach ventral to the coils of small intestine,

Development of Greater Omentum

forming a great quadrupulature of peritoneum (great omentum). This fold (see Fig. 126 C) represents the original dorsal mesogastrium and after passing downward from the greater gastric curvature and being reflected upward again reaches the dorsal wall of the abdomen at a point slightly above the line of attachment of the transverse mesocolon (q.v.). At first attached vertically in the midline, this peritoneal fold, by fusion with the parietal peritoneum later acquires an attachment which is transverse in direction and is thereby brought into contact with the upper layer of the transverse mesocolon. Fusion of the two ultimately results. This brings the floor of the omental bursa into union with the transverse colon and completes the formation of the adult gastrocolic omentum. As demonstrated in accompanying figures the transverse mesocolon of the adult is formed from 4 layers of peritoneum, i.e., the original transverse mesocolon (2 layers) plus the original dorsal mesogastrium to which it becomes fused (2 layers); and the transverse colon and its mesocolon automatically become parts of the floor of the omental bursa (see Fig. 120B).

Peritoneal Reflections Adjacent to the Stomach

The reflections of the gastric and omental surfaces of the peritoneum as encountered by the surgeon may now be traced, both with regard to the greater peritoneal cavity and the omental bursa, furnishing a review of all the changes, rotations and fusions in the upper abdomen which lead up to final conditions in this region. Beginning at the porta hepatis (see Figs. 120 or 124) a peritoneal surface extends downward as the anterior leaf of the gastrohepatic or lesser omentum passing over the ventral wall of the stomach, then downward as the anterior leaf of the great omentum; thence back upward as the posterior (fourth) leaf of the great omentum until the transverse colon is reached; the peritoneal membrane, then, after passing over the inferior surface of the transverse colon is reflected to the posterior abdominal wall as the under surface of the transverse mesocolon. Beginning at the porta hepatis again another peritoneal surface passes downward forming the dorsal leaf of the lesser omentum, covers the dorsal gastric

wall, continues downward from the greater curvature of the stomach and back upward to the transverse colon as the innermost (second and third) leaves of the great omentum (i.e. inner lining of cavity of great omentum); thence over the anterior and upper walls of the transverse colon and backward to the posterior parietes as the uppermost layer of the transverse mesocolon; and from here upward and onward to the starting point at the porta hepatis, passing along posterior abdominal wall (parietal peritoneum), under surface of diaphragm and liver (posterior margin of coronary ligament of liver). The peritoneal reflections just described form the walls of the omental bursa which is bounded, then, as follows: the pouch extends behind and below the liver and stomach, above the transverse mesocolon, within the great omentum, and behind the small or gastrohepatic omentum.

The great omentum is familiarly known as the abdominal policeman on account of the frequency with which it is found at a site of peritoneal contamination. This great peritoneal fold seems literally to seek out sites of danger such as an infected appendix, an inflamed ovary, or a leaking gall bladder; it is often found efficiently walling off an infectious process from the general peritoneal cavity. Following this lead of nature the surgeon makes use of this protecting structure in many ways to cover areas which otherwise would be denuded of peritoneum, and by it to reinforce suture lines of doubtful strength. In some instances, for example peptic ulcers which have undergone acute perforations,[159] are closed with great difficulty due to the friability of the ulcer margins; while in others, closure by simple suture proves impossible. Each suture which the surgeon employs tears through the pathological tissue, creating an opening of larger and larger caliber. Here plugs or patches of adjacent omenta prove of life-saving value. Tabs from the gastrohepatic or gastrocolic omenta may be brought over the opening without undue tension, then sutured to healthy tissue beyond the circumference of the ulcer (Fig. 128). The omental transplants are sewed with great

Surgical Uses of the Omenta

care about the ulcer margins. The employment of one such graft from each of the adjacent omenta, forming two superimposed protecting layers, is particularly advantageous. Following

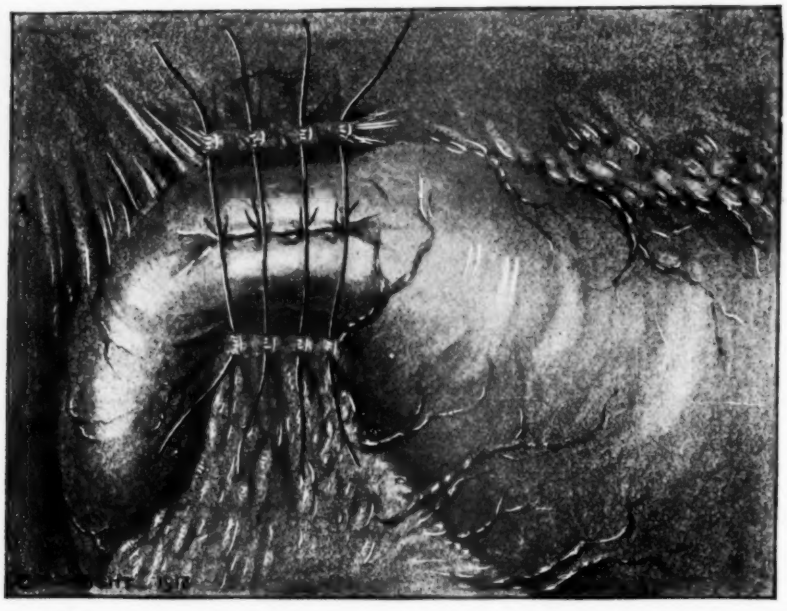


FIG. 128. Using omenta for reinforcement. Mode of closure of duodenal ulcer, whether perforating or not. The ulcer is enfolded and the gastohepatic and gastrocolic omenta are sutured or ligatured together over the intestine. (From Moynihan's Abdominal Operations, Saunders.)

closure of acute gastric perforations a gastroenterostomy may or may not be created, according to the indications as determined by the general condition of the patient and the amount of pyloric or duodenal obstruction at the site of repair.

The attachments of the stomach to the diaphragm and spleen are essentially simple; those to the pancreas are of such relative unimportance that they are as a rule omitted in any review of gastric connections, to be dealt with only under the heading of peritoneal relations of the pancreas.

Gastric Connections to the Diaphragm

The gastrophrenic ligament is a dignifying name given to a small fold of peritoneum which passes between the stomach and the diaphragm just to the left of the esophagus (see Fig. 3). It respresents the slight traction on the under surface of the

diaphragm (peritoneum) caused by the rotation of the stomach to the right. The fold is avascular and has no surgical importance. Its chief anatomical interest is the fact that it forms one of the boundaries of the so-called raw, uncovered or triangular area of the stomach in which this organ is in direct contact with the diaphragm, this being the only part of the gastric walls devoid of peritoneum with the exception of the narrow lines along the curvatures between the attachments of the omenta.

Gastric Connections to the Spleen

The union between stomach and spleen is developed in a manner analagous to that by which the stomach becomes joined to the liver. That is, the spleen originates within the dorsal mesogastrium so that the stomach no longer is joined to the posterior abdominal wall by a mesentery but to the spleen by a ligament or omentum (gastrolienal or gastrosplenic ligament; old terminology, gastro-splenic omentum). (See Fig. 95.) This peritoneal fold is continuous with the gastrocolic or great omentum. The peritoneal covering of the anterior gastric wall is continuous with that forming the anterior leaf of the gastrosplenic ligament and the peritoneum covering the posterior gastric wall is continuous with the posterior leaf of the ligament; thus one ligamentous surface is related to the general peritoneal cavity while the other forms part of the lining of the omental bursa. Within this gastrosplenic ligament run the vasa brevae or the short vessels distributed to the fundus of the stomach and derived from the splenic artery. (See Sect. III—Spleen.)

Gastric Connections to Pancreas

The two small peritoneal duplications known as the gastropancreatic folds will be fully reviewed in dealing with the pancreas. The left gastropancreatic fold contains the gastric artery (coronary artery) and during subtotal gastrectomies the vessel is sometimes ligated within the fold as it approaches the lesser curvature (Fig. 129). This peritoneal fold forms the left limb of the uncovered or triangular area of the stomach. The band known as the right gastropancreatic fold does not reach the stomach at all but passes between the head of the

pancreas and the proximal duodenum; within it is found the proximal portion of the hepatic artery. (See vessels of enteric canal.)

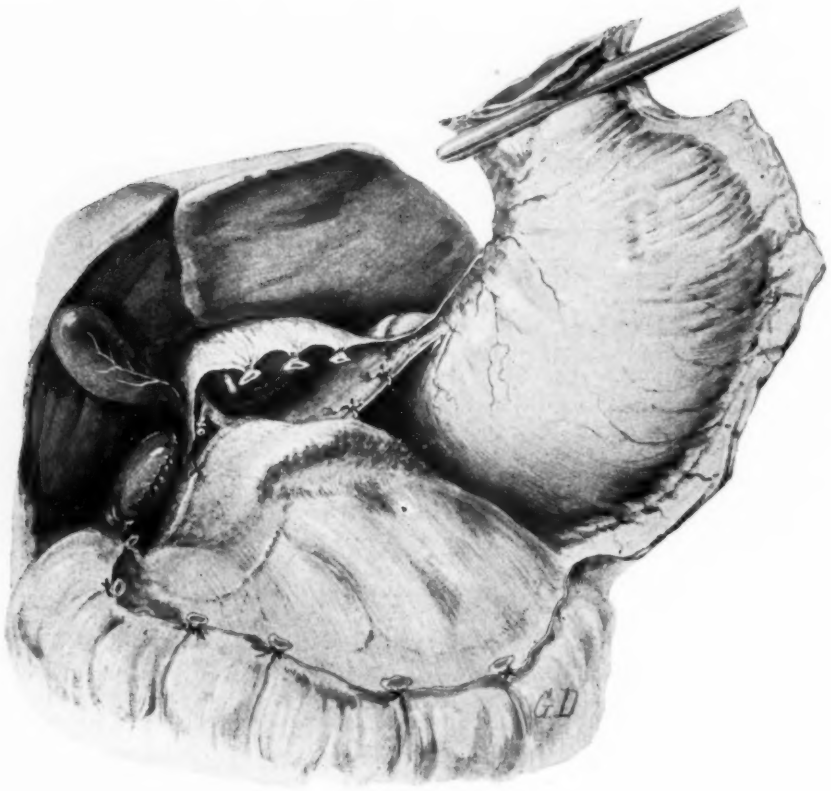


FIG. 129. Ligating left gastric (coronary) artery during partial gastrectomy. The duodenum has been divided and its distal extremity securely closed. The stomach has been raised and drawn over to the left side. Note the peritoneal fold (left gastropancreatic fold) formed by the peritoneum which surrounds the coronary artery. This fold, including the contained artery, has been doubly ligatured preliminary to its division. The gastroduodenal artery is indicated in the vicinity of the closed duodenum at the right side as it descends from its source of origin, i.e., the hepatic artery, in the pancreatico-duodenal sulcus. The transverse colon and its mesentery overlie the general mass of the small intestine (jejunoileum). (From Taylor's Operative Surgery, Wood.)

Summary

Briefly to recapitulate: The attachments or connections of the stomach are complex. All, however, are derived from the simple midline gastric mesenteries (ventral and dorsal) of early embryonic life. These peritoneal bands are termed gastric ligaments, omenta or epipla. They are double or compound

folds of serous membrane containing between their surfaces a thin sheet of extraperitoneal tissue. Omenta or gastric ligaments do not pass to the abdominal parietes but to other intra-abdominal viscera. The stomach is connected to the liver, transverse colon, biliary ducts, diaphragm, spleen and pancreas. Gastric connections are found at the curvatures only, leaving the broad surfaces of the stomach free. Of these one is related to the general peritoneal cavity and the other to the omental bursa.

Many additional practical points regarding these gastric connections suggest themselves for review. There might be studied, for example, means for gaining access to the posterior wall of the stomach, as for the performance of gastrojejunostomies; and methods for dealing with perforations, both of the pathological type, as represented by perforated and perforating ulcers, malignant and benign, and of the traumatic variety, caused by bullets and other penetrating foreign bodies or by rupture of the stomach without accompanying penetration of the abdominal walls. Again, changes in the position of the stomach with various periods of its physiological activity as the peritoneal reflections and bands allow these movements, invite attention in order that roentgenograms may be correctly interpreted, that the clinician may know at what sites gastric tumors may be palpated, and that a criterion may be gained upon which to estimate the presence or absence of gastroptosis and the relation of this condition to general visceroptosis. To deal with such topics at the termination of this postgraduate review of upper abominal inter-relationships serves both as a means of making still more clear foregoing anatomical details and of enhancing the completeness of their practical application. This particular portion of the study of the abdomen and its contents holds more interest, perhaps, for the abdominal surgeon as an operator than as a diagnostician.

Practical Topics

When an ulcer exists upon the posterior gastric wall the operator has a choice of 4 routes by which to approach the lesion. These are, the supragastric route, the infragastric

Reaching the Posterior Gastric Wall

route, the transgastric route, and the infracolic route.[160] To gain access to the posterior wall of the stomach by way of the gastrohepatic or lesser omentum (supragastric approach) the

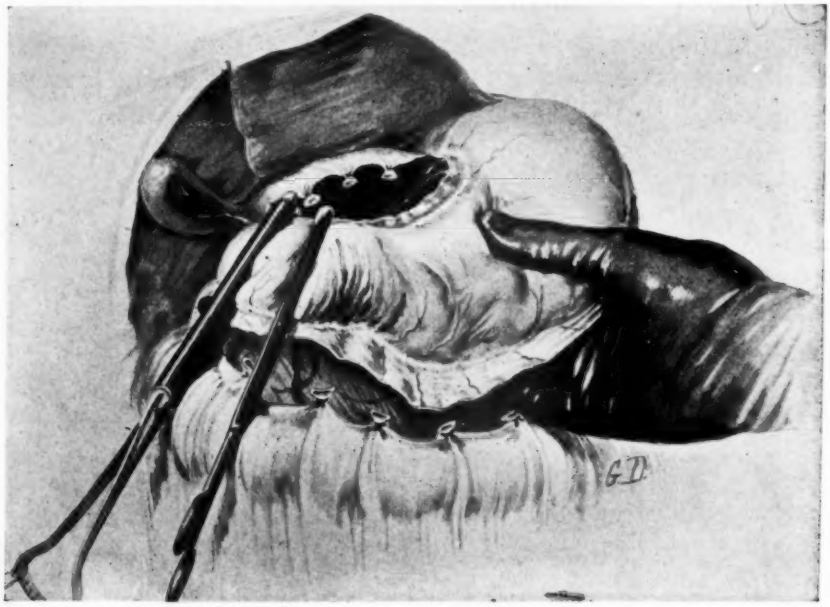


FIG. 130. Approaching posterior stomach wall and omental bursa by way of both the lesser omentum (hepatogastric ligament) and the gastrocolic ligament. (Subtotal gastrectomy). Smaller incisions through the ligaments may be used to examine the posterior gastric wall. (From Taylor's Operative Surgery, Wood.)

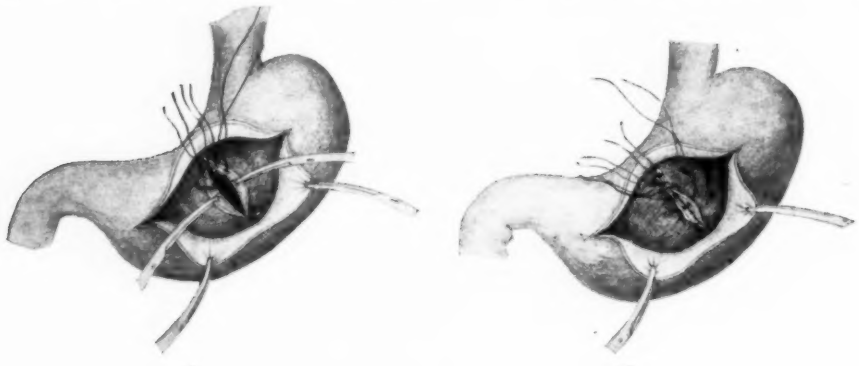
operator creates an opening of sufficient size to gain free entrance for the examining hand into the retrogastric space (omental bursa), doubly ligating and severing omental vessels if necessary; the ulcer is then freed by blunt dissection and the posterior wall with its contained lesion rotated forward and kept in view by means of a few stay sutures appropriately placed at or below the level of the ulceration. A similar procedure is employed when entering the omental bursa from below the greater curvature (infragastric approach); vessels within the gastrocolic ligament are ligated and divided, an opening is made through the ligament and the examining hand is inserted into the retrogastric space (Fig. 130). In dealing with ulcers of the posterior gastric wall by either of

these methods pads or sponges may be so introduced through omental openings to prevent general contamination of the lesser peritoneal sac.

The transgastric approach has the advantage of allowing a thorough inspection of the interior of the stomach. And this route may still be employed in cases in which ulcers are too adherent to the pancreas to be successfully rotated enough for adequate exposure from above or below. The method, however, presents the problems of how to control hemorrhage, how to prevent contamination of the omental bursa and of how to repair the posterior wall with the conventional double row of sutures. The best way in which to meet these problems seems to be the use, in addition to the incision into the anterior gastric wall, of incisions into the hepatogastric or gastrocolic ligaments, or both. Through these associated incisions gauze tampons may be packed into the bursa, as suggested, thus preventing widespread contamination; and hemorrhage from the posterior gastric wall, after the ulcer has been excised, is temporarily preventable by pressure against this tamponade, after which individual bleeding points may be caught and ligated. The technic for the transgastric approach may be summarized as follows; make an incision of convenient length (3 to 5 in.) in the anterior wall of the stomach parallel to the long axis of the organ and midway betwen the greater and lesser curvatures or opposite the site of the ulcer as palpated upon the posterior wall; ligate bleeding points; thoroughly inspect the interior of the stomach noting the size of the ulcer crater, the presence or absence of multiple points of ulceration, and making a gross differentiation between the malignancy or benignancy of the lesion; excise the lesion from the interior of the organ, using the aid of a hand of the operator or an assistant from within the omental bursa (accessory incisions as described previously); control bleeding points in the posterior stomach wall; retract the margins of the excision site on the posterior wall into the interior of the stomach, thus exposing the posterior peritoneal surface; take the desired seroserous sutures

Transgastric Approach to the Posterior Stomach Wall

(interrupted or continuous); now place the second row of sutures (through-and-through) in the posterior wall; close the anterior gastric wall in the usual manner, through-and-through



A B

FIG. 131. Repair of posterior gastric wall by transgastric route.

A. Sero-serous sutures in posterior wall.
B. Through-and-through sutures in posterior wall. Anterior wall sutured in usual manner.

row of sutures followed by a seroserous row (Fig. 131). Gastric content, if present and troublesome, is dealt with by use of a suction tube. If the ulcer is found to be too adherent to the pancreas to be successfully freed (this is rarely the case), it may be excised and left attached to the pancreas while the gastric wound in the posterior wall is sutured exactly as though the lesion had been removed.

Posterior Gastro-Jejunostomy

When the approach to the posterior gastric wall is desired for the purpose of making a posterior gastrojejunostomy this is accomplished by way of the transverse mesocolon (infracolic route): Withdraw the great omentum and transverse colon from the abdomen, turning them upward; render the transverse mesocolon taut, exposing the origin of the jejunum (for methods of locating proximal jejunum and positively identifying this loop see p. 292); apply a clamp to a bloodless point below the arch of the middle colic artery; make traction away from the omental bursa, and by a cut with scalpel or scissors, incise the transverse mesocolon near the clamp opening the retrogastric space (lesser sac); by blunt dissection carefully

enlarge the hole in the transverse mesocolon to the size of about 3 in.; push the posterior wall of the stomach through this opening by means of a hand upon the anterior gastric

FIG. 132. Closing excess opening in transverse mesocolon after posterior gastro-jejunostomy. Completed anastomosis showing opening in the transverse mesocolon to be attached to stomach or jejunum near suture line. (From Neuber.)

wall. Discussions as to the exact methods for making the actual anastomosis (Caliber of stoma; length of jejunal loop; jejunal and gastric sites) will be found in textbooks on operative surgery. After stomach and jejunum have been united any excess opening in the transverse mesocolon is closed by sutures (Fig. 132). These may include the walls of the jejunum, those of the stomach, or both directly along the line of anastomosis. This closure of the transverse mesocolon is essential if hernial protrusion of the small intestine into the omental bursa is to be avoided.

It has been stated that since the surgeon has the choice of so many approaches to gastric ulcers and may employ so many combinations of these methods, there remains, as a rule, little

reason why he should not attempt by some method (cautery, knife, exclusion, inversion) to remove the pathological process[161] with its tendencies when not removed to persistent symptoms, to acute or chronic perforation, hemorrhage, and malignant degeneration.

Bullet wounds of the stomach almost invariably involve both gastric walls; hence a wound of exit is to be sought in the presence of a wound of entrance. Exceptionally the bullet remains within the lumen of the organ after passing through a single wall while less rarely one of the gastric curvatures is wounded, tearing away a single fragment and resulting in but one hole. But a very small area of the stomach surface can be injured by a penetrating foreign body without associated injury to other upper abdominal viscera. Figure 133 c shows the location of this surface zone; it represents the superimposition of two pictures, the one showing the relations of the anterior gastric wall, the other the relationships of the posterior gastric wall. Because of the almost certainty of injury to adjacent organs the opinion has been given that operations for gunshot wounds situated above the level of the umbilicus are inadvisable.[162] And it is known that operations have been undertaken which have proved useless because uncontrolled hemorrhage from the pancreas, liver, or some large intra-abdominal vessel has lead to a fatal outcome. Instances have been recorded, also, of spontaneous recovery after perforation of the stomach (Alexis St. Martin and others). Indeed, in the early years of the World War expectant treatment of upper abdominal penetrating wounds was the rule with all combatants.[163] According to Ochsner, however, "it was soon demonstrated that most penetrating wounds of the abdomen should be operated upon early," that the policy of "look and see" proved preferable to that of "wait and see," and that it became "mainly a question of excluding the few cases in which it was best *not* to operate" (those in extreme shock; those seen long after injury; those limited to

Bullet Wounds of Stomach

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the liver area, etc.). Regarding bullet wounds acquired in civil life, there seems almost uniform agreement, that "accumulated experience shows the wisdom of operation"; that and in every

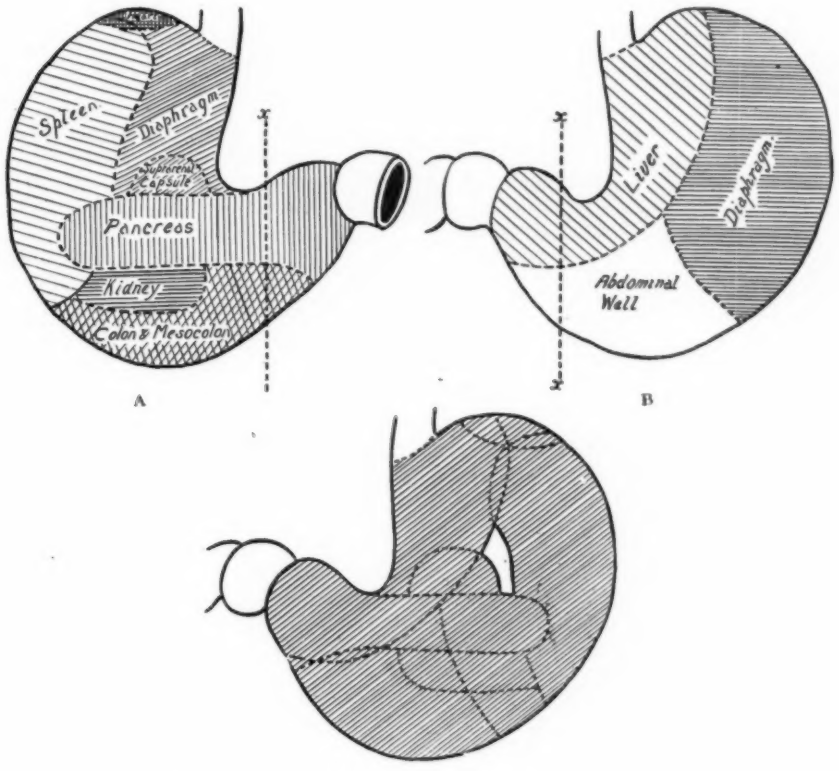


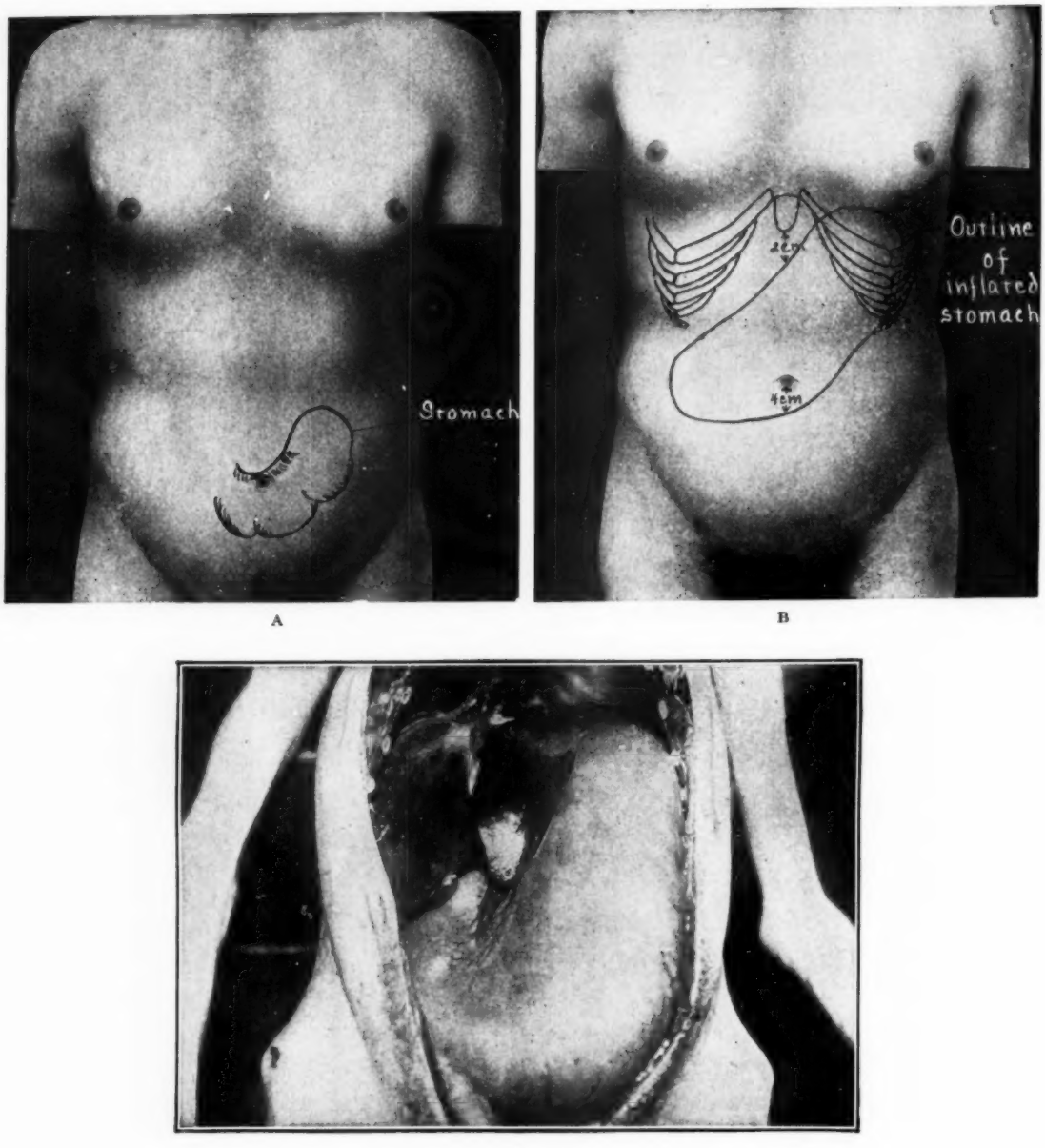
FIG. 133. Gunshot and stab wounds of stomach.

A. Relations of posterior wall of stomach. (Testut.)

B. Relations of anterior wall of stomach. (Testut.)

C. A and B superimposed. The unshaded area shows only part of the stomach which can be wounded without injury being done to other organs. (Forgue and Jeanbrau.)

case of suspected penetrating wound of the abdomen operation "on principle" should be performed "with the utmost expedition." Strong evidence that this course is by great odds the safest procedure is summarized on p. 95; and end-results, it is known, are in direct proportion to the promptness of operative intervention. Exploration should be thorough, for with multiple injuries some sites of damage are easily over-



A B

C

FIG. 134. Variations in position of stomach.

A. Gastroptosis. Note: this position of the stomach was associated with general splanchnoptosis but the model used for demonstration shows none of the thoracic or abdominal configuration actually observed with the patient.

B. Gastric dilatation associated with pyloric obstruction from chronic peptic ulcer. (A and B from Cabot.)

C. Extreme gastric dilatation due to duodenomesenteric ileus. (From Johnson's Surgical Diagnosis, Appleton.)

looked. With gastric perforations damage to the small intestine, colon, omenta, mesentery, liver, pancreas and kidneys are to be suspected, depending upon the track taken by the bullet; injury to the diaphragm is to be kept in mind with the possibility of diaphragmatic hernia formation. Even when the condition of the patient (shock, hemorrhage) seems poor the exploration should be systematic and complete; otherwise the operation for bullet wounds is but a sham. The posterior gastric wall may be approached by any of the methods described and gastric wounds of either or both surfaces are to be closed by a double layer of sutures (through-and-through layer covered by seroserous layer) while omental patches or grafts may be used as reenforcement if desired.

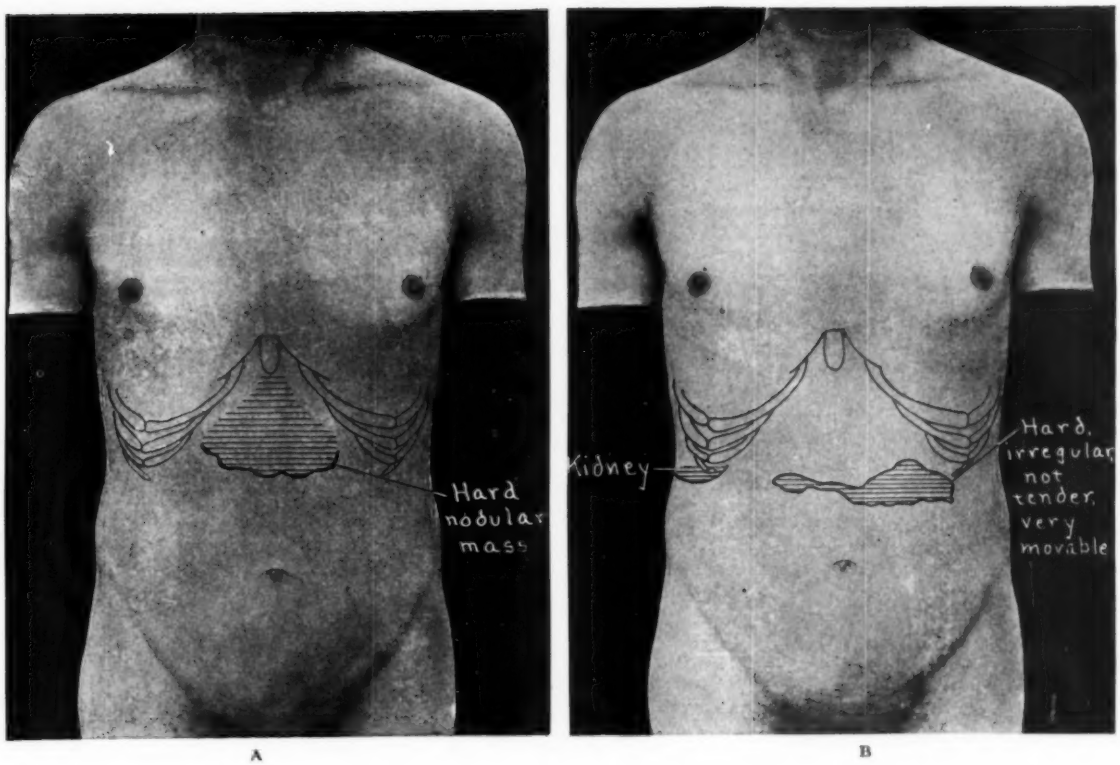
From the foregoing study of gastric attachments it is evident that the only truly fixed portion of the stomach is at its esophageal extremity (cardia and raw or triangular area). The lesser curvature is relatively fixed by the suspending lesser omentum but by this arrangement the stomach naturally suffers displacements with displacements of the liver. The greater curvature is freely movable, the stomach sliding easily over surrounding peritoneal surfaces, movements being particularly facilitated by the presence behind, of the omental bursa (Fig. 134 A–C). The diagnosis of gastroptosis was formerly more often made than at present. And operations devised to correct this supposed defect have largely passed from favor. The greater curvature in over 80 per cent of healthy men and women extends, after a barium meal, well below the interiliac line and with great frequency into the pelvis. The tonicity of the gastric musculature and the weight of the gastric contents play important rôles in determining the level of the organ within the abdomen. Based upon roentgenographic evidence regarding the position of the stomach in healthy adults it has been concluded that "many patients and many physicians have in the past been unduly concerned about so-called low positions of the stomach."[164] Unless the patient is of the

Gastroptosis

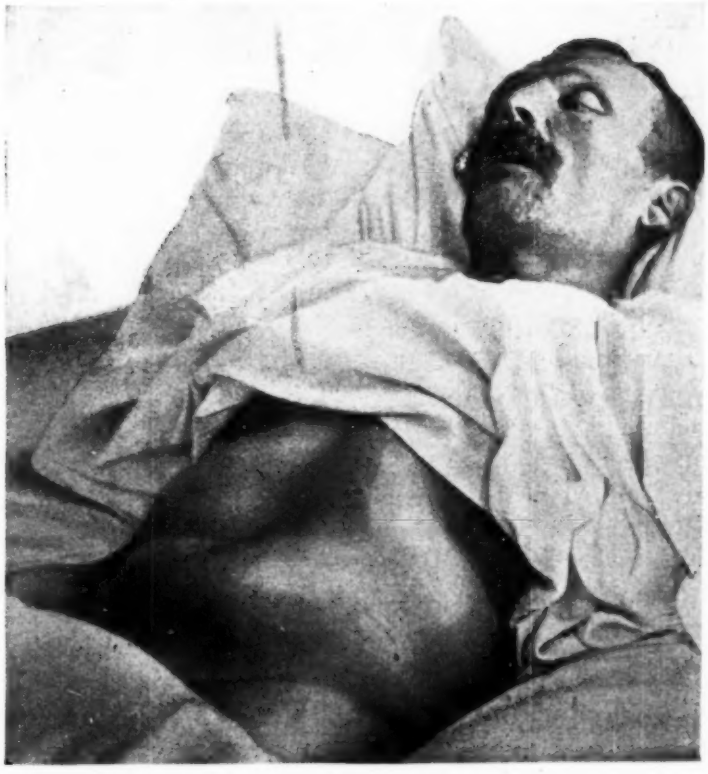
enteroptotic habitus or has definite evidence of ptosis of other viscera the diagnosis of gastroptosis as an isolated entity seems seldom to be warranted.

Because of the extreme variability as to the position of the normal stomach at various phases of its physiological activity gastric newgrowths may be palpated at widely different points. More than one-fourth of all carcinomata are situated in the stomach; and 80 per cent of patients with cancer of the stomach present at some time in the course of the disease a palpable gastric tumor. Notwithstanding these striking figures and the extreme frequency of such masses, palpable tumors do not play the important part in the diagnosis of cancer of the stomach which might be expected. Both a palpable mass and a visible gastric outline due to pyloric obstruction are relatively late signs (Fig. 135A–C). And for early diagnosis, the prime requisite to successful treatment, laboratory data (occult blood; positive roentgenogram) take decided preference over the findings upon physical examination. Not only are palpable masses relatively late in developing but the absence of such a mass is not an index of the absence of cancer. Every experienced clinician has met with cases in which the roentgen ray has demonstrated extensive malignant involvement of the stomach later confirmed by operation or autopsy, where repeated painstaking physical examinations have failed to give the slightest assurance that the lesion was present. Numerous factors contribute to the ease with which gastric growths may escape detection; the pyloric extremity of the organ is at times lodged below the margin of the liver and when the stomach is full the pylorus may be pushed 2 in. to the right of the midline; cancers of the cardia cannot be felt; and tumors on the lesser curvature, posterior wall and fundus often are difficult to map out since normally only the lower part of the greater curvature comes in contact with the anterior abdominal wall. In addition to being of rather late development and readily escaping detection masses, even when present, may

Gastric Cancer and Palpable Tumors



A B



C

FIG. 135. Late physical signs with gastric carcinoma; palpable mass; visible gastric outline from obstruction.

A. Carcinoma of greater curvature. (From Cabot.)

B. Carcinoma of greater curvature and gastrocolic omentum. (Cabot.)

C. Carcinoma of pylorus with pyloric obstruction causing visible gastric distention. (From Quervain.)

defy positive identification. It is not always easy and is at times impossible to state either that the mass is situated within the stomach or that it is malignant in character. So great is the range of gastric movements (epigastrium umbilical zone, hypogastrium, hypochondria) and so many are the other masses common within this wide range (tumors of gall bladder, liver, pancreas, mesentery, transverse colon, small bowel) that absolute identification of gastric growths proves most difficult.

To attempt the diagnosis of gastric cancer, then, by bedside methods alone is to give up hope of early diagnosis, [165] which is somewhat akin to giving up hope of obtaining favorable results from treatment; and to render a prognosis upon information obtained by physical examination alone, without aid of laboratory data or exploratory incision, implying as this does that the diagnostician is *positive* the mass in question is located within the stomach and is *certain* that it is malignant, is both unwise and inconsistant with the importance of the prognostic judgment to the patient and to relatives.

B. ANATOMICAL AND PHYSIOLOGICAL DIVISIONS OF THE GASTROINTESTINAL TRACT

1. ANATOMICAL DIVISIONS. The enteric canal has both anatomical and physiological divisions. These are quite distinct from each other as to location and limits and will be studied separately. Reference to the former has been freely made in foregoing pages and they will here be but briefly considered for with these divisions the practical surgeon is of necessity thoroughly familiar. Such knowledge is implied even by the names of the various operations and these could not be performed without comprehensive acquaintance with anatomical details. The procedure, for example, by which the gall bladder is united with the enteric canal is termed as cholecystogastrostomy, cholecystoduodenostomy, cholecystojejunostomy, or cholecysto-transversostomy, depending upon the exact point in the gastrointestinal tract utilized for the anastomosis.

The names applied to the several anatomical divisions of the alimentary canal are largely terms descriptive of certain gross

appearances. The first portion of small bowel, a loop approximately twelve fingerbreadths in length, is the duodenum (L. *duo*, two + *denum*, ten); the subjecent portion which is usually found to be empty when examined post mortem, is the jejunum (L. *jejunus*, empty); that especially tortuous distal third of small bowel is the ileum (Gr. *ileo*, I roll up; twist); the closed end of large bowel is the cecum (L. *caecus*, blind); the small worm-like unit attached to this pouch is the vermiform appendix (L. *vermis*, worm + *forma*, form) (L. *ad*, to + *pendere*, to hang). The terms intestinum crassum (L. *crassus*, coarse; thick, wide) and intestinum tenue (L. *tennis*, thin, fine) distinguish by calibre the two main intestinal divisions, large and small. The word esophagus comes from two root-words meaning to eat and to carry, hence the name fittingly describes this 9 in. musculomembranous tube extending from pharynx to stomach, as a passage way for food. The pylorus (Gr. a gatekeeper) guards and controls the lower orifice of the stomach. The word bowel (L. *botellus; botulus*, sausage) describes the shape of the tract but also signifies something deep in situation, while the term intestine (L. *interaneus*, interior) likewise indicates the position of the alimentary tract (L. *alimentum*, food), which together with its glandular outgrowths as already noted practically fills the belly (a muscular bag).

Terminology

The dividing lines separating anatomical units are easily recognized. The esophagus is separated from the stomach by the cardiac sphincter; the union of stomach with duodenum is marked internally by the pyloric ring and externally by the visible pyloric vein (Mayo's vein); the jejunum begins at the point where the small bowel pierces the transverse mesocolon; the ileum ends at its junction with cecum (ileocecal valve); which also marks the beginning of the ascending colon; the transverse colon terminates at its two extremities in colic flexures (right and left); the descending colon ends opposite the left iliac crest.

Anatomical Boundaries

The single divisional point which the operator cannot exactly locate is the junction of jejunum with ileum for this is an

Jejunoileal Junction

indefinite blend, the ileum being roughly the last 12 ft. of small bowel. Small bowel measurements are made either downward from the duodenojejunal junction or upward from the ileocecal

FIG. 136. Method for determining the real direction of an isolated loop of intestine by palpation of the mesenteric root. (From Monks, *Surg. Gynec. Obst.*)

valve but cannot be taken from the jejunoileal union since this is but an arbitrary point of blending of these divisions.

Intestinal Localization

This lack of any fixed and readily located landmark within the jejunoileal portion of small bowel is a decided handicap for the operator since it leaves him without a simple means of orientation with regard to approximately 20 ft. of bowel. How is he to know in handling individual intestinal loops which extremity is cephalad and which caudad; how is he to estimate the distance of the various segments from duodenum or cecum unless he traumatizes all intervening bowel by taking actual measurements? In creating intestinal anastomoses or stomata, in seeking points of intestinal obstruction, and in numerous circumstances and for various reasons it is important that the surgeon be able to identify, at least roughly, the portions of bowel with which he deals.

Monks has shown that the determination of direction in any intestinal loop may be made by examining the relation of the loop to the root of its mesentery. The procedure is as follows:[166]

Draw the loop in question well upward in the abdominal wound; direct an assistant to hold the loop by its extremities within the plane of the mesenteric root (Fig. 136); now ascer-

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tain by inspection or palpation whether there is or is not a twist within the mesentery supplying the loop; if no such twist exists it naturally follows that the upper extremity of the loop

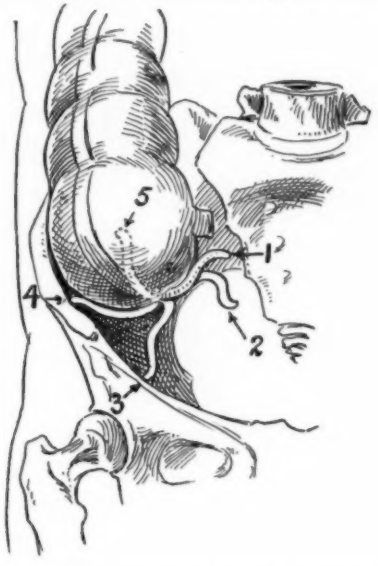


FIG. 137. Various positions occupied by the appendix. (From Deaver.)

is its cephalic end while the lower extremity of the loop is its caudal end. If upon palpation it is determined that a twist exists in the mesentery of the bowel, the loop should be rotated and palpation repeated; when no twist remains, the upper extremity of the loop as it is then held, is nearest the duodenum and the lowest extremity is the one nearest the ileocecal junction. In determining whether or not a twist exists in the mesentery of the loop in question, the surgeon may grasp the intestine in such a manner that his thumb is on one side of the mesentery and his fingers upon the other and by pushing his hand toward the mesenteric root he may conduct his examination by gently sliding his hand upward or downward along the base of the mesentery. Or, the mesenteric root may be palpated by passing the open hand along one side only. Again, the surgeon may determine the condition of the mesentery by traction on the wound margins and by inspection.

Palpation of the Root of the Mesentery

The terminal ileum may be located by finding the ileocecal junction as the finger is passed from above downward along

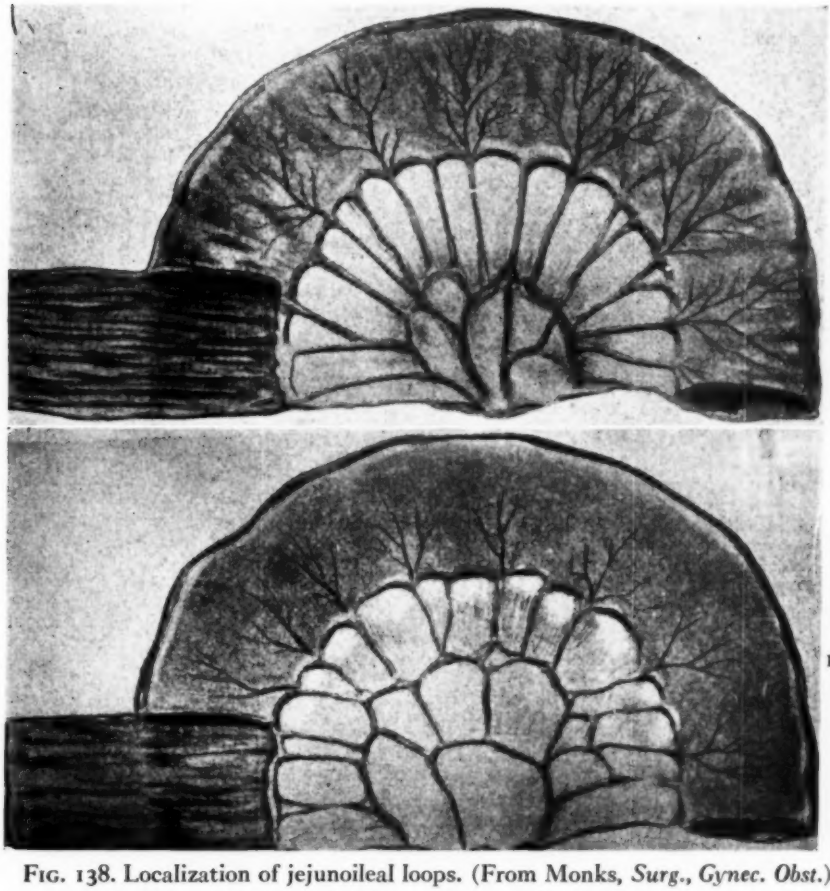
the medial border of the ascending colon. At times the ileocecal junction may lie within the pelvis minor. In such instances the examining finger must pass over the right psoas muscle and iliac vessels before encountering the terminal ileum. The base of the appendix is found springing from the medial and posterior part of the cecum about 1 to 1½ in. below the ileocecal orifice. The anterior tinea of the cecum forms the surest guide to the base of the appendix. The appendix (tip) has been found in every possible situation within the abdomen which the location of the cecum and length of the appendix and meso-appendix allow.[167] The appendix usually courses over the pelvic brim, upward behind the cecum, or upward and medially toward the spleen (Fig. 137).

Finding the Terminal Ileum and the Appendix

The differentiation between loops of ileum and those of jejunum is frequently of great importance. As pointed out there is no sharp demarcation between these portions of the small bowel and variations in structure and appearance between them take place gradually. Differences are, naturally, most marked near the extremities of the respective anatomical divisions and by being acquainted with these variations the surgeon may estimate with fair accuracy the identity of the particular loop of bowel which he may chance to encounter and desire to localize. Credit for emphasis upon these details for localization belongs chiefly to Treves and to Monks. It is largely from the writings of the latter that points which follow are derived.

The essential differences between the upper and the lower limits of the small intestine supplied by the mesentery proper (mesenteriolum) may be summarized thus:[166] In the proximal jejunum the loops are, as a rule, larger; have thicker walls; are more vascular; have more marked plicae circulares (valvulae conniventes); and are supplied with fewer and smaller lymphatic patches; their mesenteric attachments have larger, straighter vessels and are more translucent and free from fat tabs (Figs. 138 A and 139 A). Upon the other hand in the terminal ileum the loops are smaller; have thinner walls; are less vascular;

have few or no plicae circulares; and are plentifully supplied with large lymphoid patches (Peyer's patches) (see absorptive functions); their mesenteric attachments have smaller, arched



138A

138B

FIG. 138. Localization of jejunoileal loops. (From Monks, *Surg., Gynec. Obst.*)

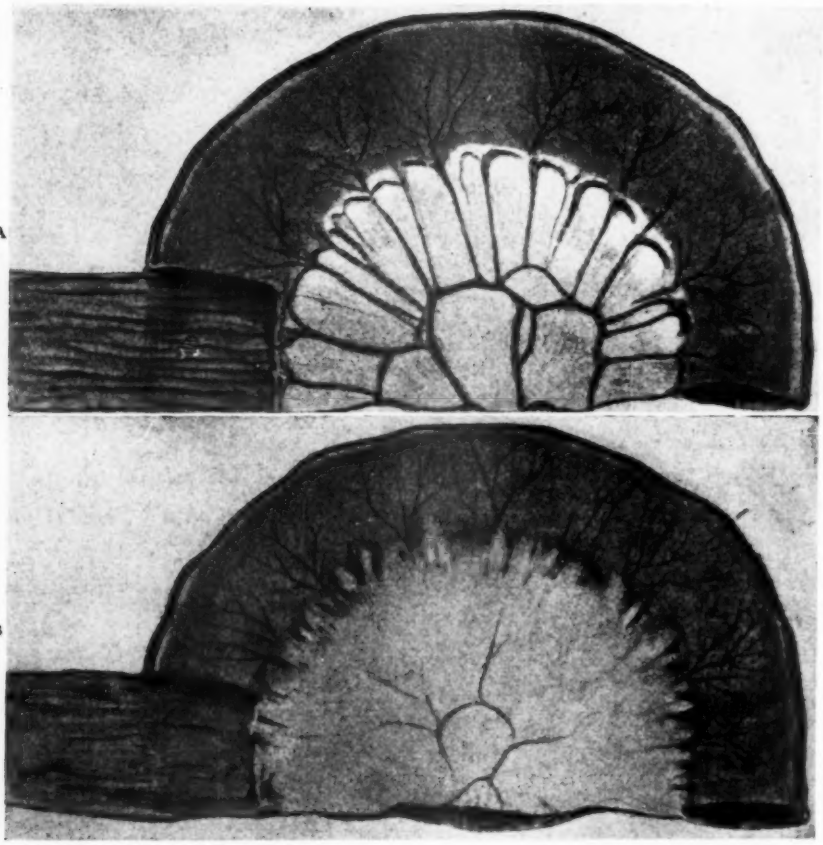
A. Upper jejunum. Note, size, thickness and vascularity of bowel; also the abundant coarse valvulae conniventes. Observe that vascular arches in omentum are largely primary and that bowel wall is reached by vessels which are large, long, and straight. (Obviously a segment of high digestive or functional activity.)

B. Lower ileum. Note bowel is smaller caliber, thinner texture, and less vascular (i.e., vessels pass but short distance to bowel wall and arborize but little); valvulae conniventes are fewer and smaller (obviously a loop of less functional importance). Observe that the vascular arches in the omentum have secondary and tertiary loops while the bowel is reached by vessels which are shorter, and somewhat tortuous.

vessels, and are more opaque and laden with fat (Figs. 138 B and 139 B). These differentiating characteristics will be individually emphasized.

Size: The normal size of the jejunal (upper) loops is from 1¼ to 1½ in.; that of the ileum is about 1 in. in diameter. In pathological states these normal measurements may be lack-

Jejunum vs. Ileum



139A

139B

FIG. 139. Showing same differences between upper and lower loops of small intestine (jejunoileum) as illustrated in Figure 138 but in a fatter individual. (From Monks, *Surg., Gynec., Obst.*)

A. Upper loop.

B. Lower loop.

Observe differences of fat distribution in upper and lower loops and in B (low loop) the little tabs of fat encroaching upon the wall of the intestine itself, a condition typical in lower ileum.

ing, the caliber of the bowel depending largely upon the tonicity of the musculature, being small with spasticity and large or dilated in relaxed states. Thus, while, one might carelessly assume that the small intestine would grow larger and larger as the large intestine was approached, the reverse proves

true. Indeed, this is analagous to the condition in the large bowel where the proximal portion (cecum and ascending colon) is of much larger caliber than the distal portion (descending and iliac colon).

Thickness: The jejunal walls are heavy and thick suggesting an ample musculature and a high degree of physiological activity. The ileal walls are light and thin in comparison and lack the fleshy feeling noted in the upper jejunum.

Valvulae conniventes: As the intestinal loop is gently stroked between the thumb and forefinger the plicae or transvers folds may be felt as the fingers roll over them. These are abundant high in the small bowel and scanty or wanting in the terminal ileum.

Lymphatic patches: Upon the other hand the localized accumulations of lymphoid tissue (Peyer's patches) are more abundant from above downward, being numerous in the terminal ileum. It is not always easy to make out these patches by palpation.

Vascularity: Little vessels, the vasa recta, pass onto the intestinal walls, coming from the mesenteric arches and ramifying or arborizing upon the bowel wall transverse to its long axis. These alternate, as a rule, from one side to another (see Fig. 138 A). Upon the jejunum this supply to bowel wall is rich, the vessels being longer, more branched and more numerous than in the ileum where they are short, scanty, and largely devoid of arborization.

The main vessels of the superior mesenteric artery unite to form a series of arches with their convexities directed toward the intestine. In the upper jejunum these arches tend to be placed at a distance from the intestinal wall, and are usually single or primary and from these primary arches, long vessels of large caliber, pass in a straight course from the depths of the mesentery to the bowel. In the ileum the arches in the mesentery are more numerous forming secondary and tertiary arcades; while the vessels passing to the bowel are shorter, more tortuous and of smaller caliber.

Mesenteric fat: In the terminal ileum the fat present may obscure the vessels and the mesentery appears very thick and opaque while characteristic little tabs of fat pass from the mesentery onto the wall of the intestine. In the jejunum the vessels are more readily visible and the mesentery thinner and more translucent while fat tabs do not tend to pass to the bowel wall.

As would be expected there is much variation in different individuals as to the total amount of fat present, but in general the difference in distribution between the upper and the lower portion of the mesentery is quite obvious.

In summarizing his work Monks wrote: "It is not by any one of these signs, but by a combination of them, that the surgeon makes his estimate as to the level of bowel to which the isolated loop belongs; while his localization may not be very exact, when he needs the information the localization, as he has made it, is probably better for his purpose than no localization at all."

Mesenteric Cysts

Cystic masses occur within the mesentery but the diagnosis of mesenteric cyst is solely one of position since these tumors vary considerably as to pathological character. Mesenteric cysts may be lined by mucous membrane (misplaced or embryonic intestinal tissue) endothelial cells (distention of closed peritoneal pouches) or other tissues (dermoid cysts, lymphatic cysts, single or chylous, remnants of Wolffian body).[168] These cysts are rounded, well defined, tense, elastic and movable; they are usually located upon the right side of the abdomen below the umbilicus. Since their only connection is with the mesentery or intestine a physical sign of some value is the ability to move the mass freely from side to side (upon the mesenteric hinge) but little or not at all at right angles to this direction (i.e. up and down). These rare tumors may cause symptoms ranging from slight abdominal fulness or a vague sensation of discomfort to recurrent attacks of colic and vomiting or acute symptoms of intestinal obstruction due to kinking of the bowel; at times the interference, the functional

integrity of intestinal vessels and nerves produce symptoms of spastic constipation or the opposite, those of gastroenteritis.

Aside from difficulties relative to intestinal localization and in differentiating loops of ileum from those of jejunum, the only other common point of confusion, regarding the anatomical divisions of the gasterointestinal tract concerns that portion of large bowel known as the sigmoid colon. This term does not appear in the Basle International Anatomical Nomenclature (B. N. A.) but is frequently encountered in clinical texts; and the "sigmoidoscope" is a well known part of the surgeons' diagnostic armamentarium. Correctly speaking the portion of bowel between the end of the descending colon (at the level of the left iliac crest) and the beginning of the pelvic colon (medial border of left psoas major muscle) is termed the iliac division, while the bowel which extends from this last named boundary to the junction with the rectum (at about the level of the third sacral vertebra) is known as the pelvic colon. The iliac colon is from 5 to 6 in. in length and has no mesentery; the pelvic colon is from 16 to 17 in. in length and is supplied by a mesentery of considerable width. The term sigmoid colon, or omega loop, by some authorities is applied to all of the bowel from the iliac crest to the level of the third sacral vertebra (i.e. to both iliac and pelvic divisions) making a segment partly with and partly without a meson. Other authorities use the terms sigmoid colon and pelvic colon synonymously, as referring exclusively to that portion which has a mesentery. The practical point to be noted is this: an instrument passed through the rectum must be about 30 in. long to reach the end of the descending colon (if indeed this be the upper limit of the sigmoid) or 23 in. to reach the upper limit of the pelvic colon (if this be considered the upper end of the sigmoid). But the instrument commonly termed a sigmoidoscope is only from 10 to 12 in. in length. It is clear, then, that in passing a 12 in. instrument into a 20 to 30 in. canal, the end of the segment cannot be examined; and it cannot be said after a sigmoidoscopic examination that "there is no

The Sigmoid Colon

Level of the Sigmoidoscopic Examination

newgrowth or abnormality within the sigmoid colon." Cases will be noted in which a roentgenogram will reveal a sigmoid mass while in the same case a rectal consultant will state that the sigmoidoscopic examination is negative; the explanation of the apparent discrepancy being that the mass is located within either iliac or pelvic colon but at a distance of more than 15 in. from the anus (beyond sigmoidoscopic vision). It seems advisable to refer to a sigmoidoscopic examination in terms of the specific number of inches or centimeters from the anus traversed by the instrument and to drop the use of the term sigmoid colon in favor of the more exact terms, iliac colon and pelvic colon.

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EPONYM

HENRY HEAD* (English physician. Contemporary)

Head's Areas
Head's Zones

"Areas of cutaneous hyperalgesia occurring in cases of acute or subacute visceral disorders."

Discussion of Eponym

The accompanying photostatic copy of excerpts from Head's original article shows that he had a dual object in mind in writing his paper, first of investigating the pain and accompanying tenderness consequent on visceral disorders and second of mapping out on the surface of the body the skin areas supplied by the various segments of the spinal cord. That is, he studied in part viscero-cutaneous relationships and in part spinal segmentation without reference to visceral diseases.

This dual nature of the paper and the completeness of the theoretical charts and cuts appended, caused some confusion and misinterpretation. Head himself carefully pointed out that certain of the skin zones which he delimited by his investigation were never involved as a result of visceral disorders. These zones represented silent areas and he referred to them as "gaps." He also observed that skin tenderness seldom completely filled cutaneous cord zones but was rather to be found at fixed points known as "maxima," situated somewhere within the zonal boundaries. Notwithstanding his emphasis upon such matters textbooks appeared shortly after publication of his paper which reprinted the surface maps or "Head zones" with notations to indicate that every surface zone in the body was related to some internal organ and that when any organ was diseased skin tenderness would be found neatly distributed over some surface segment which was diagnostic of involvement of that particular organ. Such ideal pictures naturally were not found upon physical examination. And early attempts to over-apply Head's observations without regard to many details which he insisted were important, and made in advance of more laborious and complete clinical investigations of individual viscera to determine the relative frequency with which each caused surface changes and of the type of disease or stimulus which set up such changes, brought suspicion and some discredit upon the whole theory of viscero-cutaneous phenomena. Among requirements pointed out by Head as important in intelligent use for diagnosis of surface sensory changes caused by visceral disorders are a careful, deliberate, and systematic sensory examination; separate study of the various forms of skin sensitivity; an understanding of differences between peripheral nerve distribution and spinal segmentation; knowledge concerning the sympathetic nervous system and of why certain surface zones are clinically silent or represent gaps with regard to visceral diseases. Head also emphasized the importance of properly interpreting the relation between maximal points of tenderness (maxima) and segmental areas in their entirety; also of being conversant with the "laws of spread" of cutaneous disturbances originating at fixed points, to other regions or more remote segments (sensory "generalization"). Some understanding of such matters is a prerequisite to an evaluation both of viscero-sensory phenomena in general and to Head's contribution to this phase of clinical diagnosis.

In his pioneer work Head acknowledged the antecedent studies of Ross and others regarding the reference of pain caused by visceral diseases to definite areas of the body wall. He highly evaluated the contemporary investigations of Mackenzie who was the first to point out the presence of tenderness within areas to which pain was referred and to suggest the use of such tenderness as an objective sign in testing for body wall changes

*A sketch of the life of Head will appear when this material is published in book form.

BRAIN:

A JOURNAL OF NEUROLOGY

EDITED

FOR THE NEUROLOGICAL SOCIETY OF LONDON

BY

A. DE WATTEVILLE

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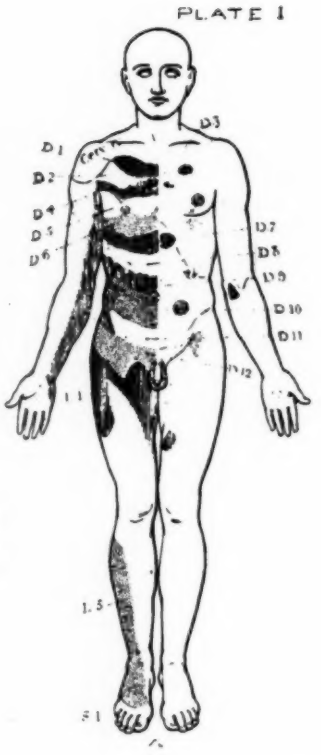
PLATE I



BRAIN.

PARTS I. & II., 1893.

Original Articles.

ON DISTURBANCES OF SENSATION WITH ESPECIAL REFERENCE TO THE PAIN OF VISCERAL DISEASE.[1]

BY HENRY HEAD, M.A., M.D.
University College Hospital.

INTRODUCTORY

SEVERAL years ago I was led to examine the positions occupied by pain in disorders of the stomach and I soon came to the conclusion that the usual description was incomplete in several respects. For firstly the positions over which the patient experienced pain in gastric disturbances were more numerous than was usually supposed, and secondly the pain was in many cases associated with definite cutaneous tenderness. Moreover the cutaneous tenderness was in many cases not confined to small spots or areas, but occupied whole tracts of skin with definite borders. I was thus led to investigate the pain and accompanying tenderness consequent on disturbances of other organs, and I found that these sensory disturbances also followed definite lines.

After Ross's most suggestive papers it seemed exceedingly probable that these areas bore some definite relation to nerve distribution, and I then began to investigate the distribution of herpes zoster in the hope that a skin lesion which was notoriously of nervous origin might throw some light on the meaning and significance of the tender areas in visceral

[1] Read as a Thesis before the University of Cambridge, June, 1892, and before the Neurological Society of London, November 10th, 1892.

disease. To my surprise I found that the areas occupied by herpes zoster exactly corresponded to those with which I was familiar in visceral disease.

I next attempted to determine to what level of the nervous system these areas belonged, with the help of cases in which gross organic lesions were present. By this means it became apparent that each of these areas represented the distribution of either a single nerve root or of a single segment in the spinal cord.

Thus I was enabled to map out the areas supplied by the various segments of the cord on the surface of the body. It then became apparent that certain of these areas were never affected in visceral disease, and this led me to examine the sensory supply of the viscera from the sympathetic system. Now Ross had already suggested that in visceral disturbances pain (and therefore in my cases tenderness) was referred along the distribution of the somatic nerves which came off from the same part of the cord as the sensory sympathetic fibres to the organ affected. Thus if I could map out the somatic areas along which pain was referred in visceral disease I could say, on Ross's hypothesis, what was the sensory supply from the sympathetic of the particular organ affected. By this means I obtained another scheme showing the distribution of the sensory sympathetic fibres analagous to that which Gaskell constructed for the motor and inhibitory fibres of the same system.

The next question that arose was whether these tender areas appeared only in visceral disease, and I soon found that they appeared to a greater or less extent in many general diseases, such as anæmia, ague and fever of all kinds.

In the present paper I shall confine myself to the discussion of the disturbances of sensation, &c., below the level of the clavicles, for although every general statement applies equally to the head and neck and the body below the clavicles, the problems opened up by a consideration of the areas of tenderness occurring in the head and neck are so wide reaching that I must reserve them for a subsequent paper in the near future.

FIG. 140A. Facsimile of introduction and plate from Head's original article.

If impulses pass up the sensory nerves from an organ which is diseased to the cord they will set up a disturbance in the segment of the cord to which they are conducted. Now any second sensory impulse from another part conducted to the same segment of the cord will be profoundly altered. Under normal circumstances it would have set up its own proper disturbance in the grey matter and this disturbance would have been conducted to the brain. But now it no longer falls into a normal and quiescent cord but into one whose activity is already disturbed. The resultant stimulus conducted upwards is therefore a very different one from that which would have passed on under normal circumstances. In many cases the second stimulus will be exaggerated like rays passing to the eye through a convex glass. Thus if any segment of the cord is disturbed by painful stimuli from an internal organ a stimulus applied to the skin over the areas supplied by the nerve roots belonging to this segment will be exaggerated and a stimulus which normally was perhaps only uncomfortable would now appear to be very painful.

[redacted]

Thus, as our viscera are so notoriously insensitive, and as we have never had the opportunity of developing the sense of localisation in them, owing to their inaccessibility to touch, it is not to be wondered at that the maximum pain is not felt in the organ affected. They are thus as regards the localisation of sensation in exactly the position of the area on the skin whose sensation of pain was diminished in comparison with that of its neighbours. A painful stimulus to an internal organ is conducted to that segment of the cord from which its sensory nerves are given off. There it comes into close connection with the fibres for painful sensation from the surface of the body which also arose from the same segment. But the sensory and localising power of the surface of the body is enormously in excess of that of the viscera, and thus by what might be called a psychical error of judgment the diffusion area is accepted by consciousness, and the pain is referred on to the surface of the body instead of on to the organ actually affected. I do not mean to state that pain is never referred to the organ affected. Far from it. The pain is frequently felt in the organ itself, but it is "dull," "heavy," "wearing," and not "sharp," "aching," "stabbing," like the referred pain.

Thus I believe that the phenomena of allocheiria and of referred pain in visceral disease are in nature and explanation essentially the same. Both depend for their appearance on the law that where a painful stimulus is applied to a part of low sensibility in close central connection with a part of much greater sensibility the pain produced is felt in the part of higher sensibility rather than in the part of lower sensibility to which the stimulus was actually applied.

[redacted]

§ 2. *The relation between the tender areas in visceral disease and the areas affected in herpes zoster*

Before I proceed to describe the limits of the tender areas in visceral disease, I must digress for a moment to point out how I have been helped in this investigation by certain trophic skin lesions, especially herpes zoster

[redacted]

Now these points correspond to the positions of pain and maximum tenderness in visceral disease. Thus the areas occupied by herpetic eruption correspond to those which become tender in visceral disturbance in three points.

1st. They have the same distribution.

2nd. They do not overlap.

3rd. They have the same maxima.

Thus in the herpetic eruption I had a means of actually seeing the areas I was investigating, marked out for me on the surface of the skin.[1]

[redacted]

Conclusions

We have now been able, with the help of traumatic lesions of the spinal cord, to name each area according to the spinal segment to which it belongs. Thus the dorso-ulnar area represents the supply of the first dorsal segment, and the gluteo-crural that of the first lumbar, and each of the eleven intervening areas represents the supply of one segment whose number we now know

In a similar manner we found that the gluteo-pudendal area represented the supply of the third sacral segment—the fibulo-dorsal that of the fifth lumbar, and the intervening areas have been numbered according to the segments to which they belong

We have also seen that the "gap corresponds to the second, third and fourth lumbar segments, and we have been able from the lesions produced by organic disease to approximately apportion the skin into areas corresponding to each of these segments

Introductory.

We have now seen that the whole of the body and limbs can be marked out into areas, each of which I have attempted to show, corresponds to the cutaneous distribution of the pain fibres given off from one segment of the cord. I shall now try, and put before you the extent to which these areas are affected in diseases of the various organs.

It is a well-known fact that the pain of visceral disease is not always localised by the patient over the organ affected Ross first explained this fact by the ingenious hypothesis that the pain of visceral disease was referred along the distribution of the somatic roots which came off from the same level of the cord as the sympathetic fibres to the organs affected. He collected a large number of cases of pain, and his intimate knowledge of the sensory distribution of certain roots enabled him to say definitely that in certain cases, the distribution of the pain corresponded exactly with that of certain roots.

The description given by patients of their pain is, however, so unsatisfactory, that this important work did not bear fruit to the extent that might have been expected.

An enormous advance was made when Dr. Mackenzie[1] described the cutaneous tenderness which is so frequently associated with the pain of visceral disease. For here we have a symptom which is distinctly more objective than that of pain only. He proceeded to collect a large number of cases in which the tenderness was present over one or more points, and in the course of this section, I shall repeatedly refer to his interesting paper. Although we worked independently and published at the same time, our results agree to an extent that is very flattering to me. In particular, I wish to emphasise the following points in which we are at one.

[redacted]

§ 1. *The pain and areas of tenderness in visceral disease, their characteristics, and the means for their demonstration.*

In order to appreciate the characteristics of the areas of tenderness which appear in visceral disease it is best to take an example. In the type of case which is so common in our hospitals where a patient suffers from pain after food with or without hæmatemesis, an area of cutaneous tenderness is sometimes found which can be marked out as follows. The skin and subcutaneous tissues are taken up gently between the finger and thumb at various points on the abdomen.

[redacted]

Another method for bringing out these tender areas, which is clumsy but theoretically interesting, is the use of a warm sponge or of a test tube filled with moderately warm water. As soon as the tender area is reached the patient experiences a feeling of great heat and flinches under the application. The same effect can be produced by moderate cold except that even moderate cold is at all times unpleasant to the skin of the abdomen, whilst moderate warmth is pleasant, and thus brings out the contrast between the normal and the altered sensory areas in a much clearer manner.

Another characteristic of these tender areas is the increased reflexes which can be obtained from them. This is a subject to which I shall return later, but I may mention here that whenever a portion of the skin becomes hyperalgesic from visceral disturbances the reflexes normally obtainable from that area are much increased. This is beautifully seen when the hyperalgesia affects the skin of the abdomen or buttock on one side only, so that the reflexes on the two sides can be compared with one another.

[redacted]

A still better method of marking out such an area is to take a pin with a round head of such a size that it is obviously blunt to all parts of one's own cheeks and face. Travel over the surface of the abdomen using the blunt end only, in the same way as if you were using the point to test for analgesia. In a favourable case the patient does not complain until the limits of the tender areas are reached, when he at once complains that he is intensely sore and he will even cry out that you are pricking him. Thus in a favourable case the increased sensibility is so great that the contact of the blunt head of a pin is mistaken for a prick of the point. Subsequently in this paper this phenomenon will appear in my notes of cases as "head of pin called point." In a large number of cases there is no such confusion, but the patient says that, although he knows that the blunt end is being used, it gives him great pain. He feels "sore and bruised, as if he had been beaten about the body or back."

It is wonderful how unanimous patients are in their description of the sensation produced by touching such a tender area. I for one can fully confirm the description usually given by patients of their sensation; for such tender areas when touched, give exactly the sensation produced by touching a bad bruise. Many of my readers will have at one time or another suffered from these tender areas, and will be able to bear out my description.

I must warn my readers from supposing that the patient cannot tell the difference between the head and the point of a pin on these areas. Far otherwise. The touch of the head of a pin feels to him like a prick on a normal skin surface, whilst the point gives him acute pain far in excess of that caused by a prick upon the normal skin.

FIG. 140B. Facsimile of excerpts from Head's original article.

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Conclusions

In this chapter I have described a series of areas which are tender in disturbances of the various organs. From the highest dorsal area (dorso-ulnar) I have traced 13 areas which fit into one another, and do not overlap to any appreciable extent. I have given cases of herpes zoster to show that the eruption in this disease appears over exactly the same areas as those which are tender in visceral disease.

We then passed to the buttock and the back of the leg, and marked out in a similar manner five areas belonging to the lumbo-sacral group. Between the lowest of the dorso-lumbar group, and the highest of the lumbo-sacral set is a gap which is not affected in visceral disease. This gap I shall fill in in the next chapter with the help of organic lesions of the nervous system, and a few cases of herpes zoster.

[redacted]

Thus the gap in the arm which is unaffected by visceral disease probably represents the distribution of the pain fibres of the fifth, sixth, seventh and eighth cervical segments.

[redacted]

Thus we have now filled up the gap in the leg which is unaffected in visceral disease, and seen that it probably represents the supply of pain fibres from three segments, the second, third and fourth lumbar.

[redacted]

Referred pain such as we have considered in this chapter is characterised by the following features.

1st. It tends to follow the lines of spinal segmentation rather than those of peripheral nerves. Thus on the chest it cuts across several ribs and does not follow the lines of any one intercostal space.

2nd. It tends to form bands round the body and thus in diseases of the abdominal viscera the pain may be quite as marked in the back as over the abdomen.

3rd. It is mostly associated with cutaneous tenderness, which may be quite as marked at a distance from the affected organ as in its neighbourhood. Thus gall stones are not only associated with tenderness over the area of the gall bladder in front, but also with tenderness over the ribs and spine behind. In the same way intestinal disorders may cause a band of tenderness extending round the body, not only in the loin but also overlapping the summit of the iliac crest on its way to the front.

[redacted]

I shall now give the limits of each area with its characteristics in detail, and in every case I shall give:—

1st. The area of tenderness.

2nd. The maximum spots.

3rd. The position of the pain.

4th. The distribution of a case of herpes (when possible), which corresponds to the area described.

Though I give bony points as the guides to these areas, I must warn my readers that they are not absolute guides, for the only true guides to these skin areas are skin points, of which, unfortunately, there are very few. Thus the umbilicus is a much safer guide to skin areas than any bony point. Men, women, and children differ to such an extent from one another anatomically, that no actual measurement from, or dependence on bony points will give us the true nature of a skin area, and although its mutual relations render its nature obvious, we should go astray if we were guided by its relation to bony points.

[redacted]

§ 3. *Topography.*

In the previous sections, I fear I may have led my reader to suppose that it would be an easy task to map out the areas of tenderness in visceral disease for the whole body. This is, however, not the case in practice. The first difficulty that meets us, is the only partial appearance of the areas in the forms of maximum tender spots. Now for these maximum spots to be of value, it is necessary that the whole area to which they belong should have frequently come under the notice of the observer, and yet it is only in a small proportion of the cases that he has the chance of seeing the area in its full development.

[redacted]

I have so far spoken as if a visceral lesion always caused tenderness over the whole of its appropriate area. This is not by any means the case. In disturbances of the stomach, instead of a whole tender area such as I have described above, we frequently find two tender spots from an inch to an inch-and-a-half in diameter situated over the costal margin at about the tip of the ninth rib, together with a posterior spot generally situated near the eleventh and twelfth dorsal vertebræ, a little to one side of the middle line.

Every such area of cutaneous tenderness has one or more maximum points, the position of which is exceedingly important, for it is to the situation of these maxima that the patient refers his pain. Thus in each case, given the position to which the patient refers his pain, I can say to what area the pain belongs. For I recognise in these points to which the pain is referred the maxima of an area whose limits I have occasionally found marked out out by hyperalgesia or analgesia, their limits never materially alter or overlap.

[redacted]

So fixed are these maxima, that supposing a whole area is tender, we can confidently predict that as the disturbance subsides, the tenderness will become limited to certain points, and when the disturbance has subsided still more, pain only will be left referred to the same points as the maxima. When I come to speak of the limits and relations of these areas, I shall therefore lay stress on the position of the maxima in each area as I describe it, for these maxima give us the clue to the meaning of pain referred to various spots on the body.

[redacted]

Now I was long ago struck by the fact that in affections of the peritoneum the pain and tenderness differed fundamentally from that of referred pain, in that, although the pain is well localised, it does not follow the line of the nerve areas. Thus, for instance the patient will refer the pain to an area both above and below the umbilicus without at the same time complaining of any pain in the back or loin.

Moreover, there is no true cutaneous tenderness in peritonitis, and the tenderness that is present differs fundamentally in character from that which accompanies referred pain. If the skin only is picked up between the finger and thumb in a case of acute peritonitis the patient complains of no pain, but directly the deeper structures of the abdominal wall are included in the gentle pressure he complains of intense pain. Thus firm steady pressure as a rule relieves referred abdominal tenderness, whilst light pressure between the finger and thumb, or even the pressure of the clothes, at once elicits it. On the other hand in peritonitis light cutaneous stimulation causes no pain, but the slightest attempt at deep pressure, or even the lightest percussion, at once causes marked pain.

Again, the distribution of the two forms of tenderness differ fundamentally. The tenderness of peritonitis may be present all over the abdomen from the ensiform cartilage to the pubes and from one costal margin to the other, but it never appears at the angle of the scapula or over the sacrum and iliac crest. On the other hand, if referred tenderness extended over the area just mentioned, spots of tenderness would appear to a certainty over the ribs in the line of the angle of the scapula, over the costal margin in the eighth and ninth spaces, over the twelfth dorsal spine, over the twelfth rib, and over the last lumbar and first sacral spines. Thus the tenderness of peritonitis only makes its appearance over those points where pressure, &c., can actually affect the peritoneum, whilst referred abdominal tenderness is always present over bony points, where pressure cannot possibly produce any effect on the abdominal cavity or its contents.

Thirdly, we find that however great may be the pain caused by the peritonitis, the abdominal reflexes are not exaggerated as would have been the case if the tenderness had been cutaneous.

[redacted]

Thus in conclusion I think we can formulate the following statement. Affections of the serous cavities of the body do not cause referred pain or cutaneous tenderness, but produce local pain which follows the lines of peripheral nerves and is associated with deep tenderness over the affected point only.

[redacted]

Thus to sum up I think we may conclude that the central connections of the pain fibres from the skin and viscera are closely connected with one another. The central connections of the nerves for heat and cold, and for trophic disturbances in the skin must also be in somewhat close association, though probably not actually connected. On the other hand the nerves for touch from the skin (we do not know whether nerves for touch exist in the viscera) are widely separated centrally from those of pain. As to their paths in the cord I do not yet feel qualified to speak definitely.

FIG. 140c. Facsimile of excerpts from Head's original article.

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from visceral diseases. Head also spoke freely of his reliance upon the papers of Gaskell concerning the distribution of visceral motor, and inhibitory fibers. Not claiming originality with regard to the already well known fact that visceral disorders caused surface changes, Head set about to utilize the work of these other investigators to accomplish his own primary object, namely to map out and to identify the surface areas related to the various segments of the spinal cord. Where the use of visceral disturbances failed him (silent areas or gaps) he turned to disorders of the spinal cord itself (compression myelitis, syringomyelia) and to those of peripheral nerves and nerve roots (severed fibers) to aid in the completion of his researches. Thus Head's great contribution was the positive identification of so-called cord zones (Head zones) upon the body surface.

With regard to diagnosis these pioneer studies left much to be desired and their results have not been so certain. Presenting a limited number of case histories Head reviewed all viscera in a systematic but somewhat sketchy fashion and gave no index as to which viscera in particular set up most clear cut evidences of referred surface phenomena. He also pointed out that given skin areas might be thrown into states of altered sensitivity from disorders of more than one viscus but gave no precise methods for dealing with the element of confusion which this overlapping introduced nor for identifying the particular viscus involved in a given case by means of sensory tests. Head's acknowledgment that surface sensory changes within cord zones were in some cases due to systemic disorders or to psychic states rather than to visceral diseases left the difficulty of differentiating these widely divergent causative factors. And the problems involved in determining how to utilize most effectively for diagnosis the cutaneous phenomena from visceral diseases remained, and to a considerable extent still remains, a matter for extended study and clinical investigation.

QUESTIONNAIRE

1. To what structures is the stomach attached?
2. Of what do gastric attachments consist?
3. What is an epiploon, an omentum, a mesentery? Derivation of words?
4. To what parts of the stomach are the gastric ligaments attached?
5. Compare the attachments of the adult stomach to those of the embryonic stomach.
6. Describe the lesser omentum; the hepatogastric ligament.
7. What structures are found between the peritoneal layers of the gastrohepatic omentum?
8. How can a liver abscess rupture into the stomach without invading the general peritoneal cavity?
9. Explain the occasional finding of toothpicks or sharp bones within liver abscesses.
10. Name the important structures found within the hepatoduodenal ligament. Give their relationships to one another and to surrounding structures.
11. Describe a surgical approach to the common bile duct.
12. What is the foramen of Winslow?
13. When small bowel becomes herniated through the foramen epiploicum what part of the constriction may the surgeon safely cut?
14. Name a safe method for liberating incarcerated intestine from the foramen of Winslow.
15. Describe the origin of the foramen epiploicum.
16. What is meant by the expressions greater and lesser peritoneal cavities or sacs?
17. Describe the relationship of important structures to the surgeon's finger after it has been introduced into the foramen epiploicum.
18. How does the surgeon locate the foramen of Winslow? Why does he examine this region of the peritoneal cavity?

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19. What is meant by the following terms; omental bursa, Winslow's pouch, cavity of the omenta, retrogastric space?
20. Describe the origin of the omental bursa.
21. How do infections or infectious processes invade the omental bursa? How do foreign bodies penetrate into this space?
22. By what routes may the surgeon drain the omental bursa?
23. Describe the origin of the great omentum.
24. Describe the great omentum.
25. Trace the reflections of the peritoneum in the neighborhood of the stomach.
26. How many peritoneal layers enter into the formation of the great omentum; the transverse mesocolon; the lesser omentum?
27. Bound the omental bursa.
28. Name some of the surgical uses of the great omentum.
29. Describe the connections between stomach and diaphragm; stomach and spleen; stomach and pancreas.
30. What parts of the gastric wall are devoid of peritoneum?
31. Bound the uncovered or triangular area of the stomach.
32. Describe the gastrolienal ligament.
33. What important vessel courses within the left gastropancreatic fold; the right fold?
34. By what routes may the surgeon approach an ulcer situated upon the posterior wall of the stomach?
35. What are the advantages and disadvantages of the transgastric approach to the posterior gastric wall?
36. How may the posterior seroserous sutures be taken when closing a wound in the posterior gastric wall during the transgastric operation?
37. Describe one method by which stomach and proximal jejunum may be approximated for a gastrojejunostomy (posterior).
38. How is the rent in the transverse mesocolon dealt with at the completion of the anastomosis with a gastrojejunostomy?
39. Discuss bullet wounds of the stomach.
40. Should bullet wounds of the stomach be treated by immediate operation or by observation and palliation?
41. How frequently are other viscera injured when a bullet wound is inflicted within the stomach?
42. Define gastroptosis. State symptoms and treatment of this condition.
43. What is the normal position for the fasting stomach; for the stomach after a barium meal?
44. What percentage of all carcinomata involve the stomach?
45. How often, in examining patients with gastric carcinomata may a tumor be palpated?
46. Discuss the relative value of the physical examination and the history with patients afflicted with gastric carcinomata.
47. Does the absence of a palpable tumor exclude gastric cancer?
48. What factors mitigate against the finding of a tumor with gastric carcinomata?
49. In what topographical regions are gastric carcinomatous nodules or masses palpable?
50. Can a prognosis be ventured or definitely stated upon palpating a mass with cases of gastric malignancies?
51. Name the anatomical divisions of the gastrointestinal tract.
50. Give the boundaries separating various anatomical divisions of the gastrointestinal tract.
53. Describe the point of union of jejunum with ileum.

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54. When is it important for the surgeon to definitely localize individual parts of the small intestine?
55. How may the operator determine which is the caudal and which the cranial end in an isolated intestinal loop?
56. What is the normal location of the vermiform appendix; variations from this normal position?
57. Name distinguishing points between upper jejunal and lower ileal segments of intestine.
58. What is a mesenteric cyst? Its composition?
59. Describe the signs, symptoms and treatment of omental cysts.
60. What is the sigmoid colon? the pelvic colon? the iliac colon?
61. What is a sigmoidoscope? How much of the lower bowel may be examined through this instrument?

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